Universidade de Aveiro Departamento de Ambiente e Ordenamento
Ano 2018

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MAPEAMENTO DO CICLO DE VIDA DA CO-CRIAÇÃO DE SOLUÇÕES BASEADAS NA NATUREZA PARA ADAPTAÇÃO ÀS ALTERAÇÕES CLIMÁTICAS EM CIDADES

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Joint Masters Degree in Environmental Science – Cities and Sustainability (JEMES – CiSu) sob a orientação científica do Doutor Peter Roebeling, Equiparado a Investigador Auxiliar no Departamento de Ambiente e Ordenamento da Universidade de Aveiro e coorientação da Doutora Sandra Valente, Estagiária de Pós-Doutoramento no Departamento de Ambiente e Ordenamento da Universidade de Aveiro e da Doutora Enza Lissandrello, Associate Professor at the Planning Department of Aalborg University.

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universidade de aveiro

UNaLab URBAN NATURE LABS

European Commission

To my family and friends
To whom I belong and dedicate everything I do

o júri

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palavras-chave

Co-criação, ciclo de vida da co-criação, etapas, ferramentas, atores, stakeholders, nature-based solutions, soluções baseadas na natureza, envolvimento das partes interessadas

resumo

O aquecimento global gera impactos nas regiões urbanas e na população humana, assim como acarreta consequências para os ecossistemas urbanos, biodiversidade e serviços ambientais fornecidos a essas mesmas populações. Ao desenvolver serviços ecossistémicos urbanos e peri-urbanos com base na natureza e com uma abordagem participativa poder-se-á criar cidades e regiões urbanas mais resilientes e sustentáveis. Assim sendo, de uma forma crescente, a co-criação tem vindo a ser reconhecida como uma forma de lidar com tais problemas ambientais, ainda que métodos e ferramentas tenham sido desenvolvidos, descritos e publicados para fases específicas do processo de co-criação. Argumenta-se que o processo de co-criação é composto por diversas fases interligadas, seus atores sociais e métodos/ferramentas que necessitam de ser mapeados e integrados em todas as etapas do ciclo de co-criação. O ciclo de vida do processo de co-criação (Life Cycle Co-Creation Process – LCCCP) para soluções baseadas na natureza (Nature Based Solutions – NBS) foi desenvolvido na presente dissertação, pertencente ao programa JEMES – CiSu. Através da utilização de ciclos contínuos de melhoria, como ciclo PDCA (Planear, Fazer, Verificar e Agir; KaizenTM), ciclo DMAIC (Definir, Medir, Analisar, Melhorar e Controlar; Six Sigma) e a metodologia de *Design Thinking*, as etapas e sub-etapas que envolvem as partes interessadas e os métodos de participação dos utilizadores no LCCCP foram identificados, definidos e mapeados. Relativamente às partes envolvidas, os atores internos e externos do Urban Living Lab (ULL) foram adaptados às etapas e sub-etapas do LCCCP; para os métodos de participação, os objetivos do envolvimento das partes envolvidas (Mease, Erickson and Hicks, 2018) foram usados como guias para selecionar alguns exemplos de ferramentas que podem ser aplicadas. O LCCCP desenvolvido nesta investigação inclui cinco fases, nomedamente co-exploração, co-produção, co-experimentação, co-implementação e co-gestão (co-exploration, co-design, co-experiment, co-implement and co-manage), criando assim um modelo único de co-criação NBS com potencial de replicação.

keywords

Co-creation, life cycle co-creation, stages, tools, actors, stakeholders, nature-based solutions, stakeholder engagement

abstract

Climate change has impacts on urban regions and human populations as well as consequences for urban ecosystems, biodiversity and the environmental services they provide to these populations. Developing urban and peri-urban ecosystem services with a nature-based and participatory approach, can help achieve more resilient and sustainable environments for cities and urban regions. Co-creation is increasingly recognized as the way forward to deal with such environmental issues, though associated methods and tools have been developed, described and published for specific stages of the co-creation process. It is argued that the co-creation process comprises various interlinked stages, corresponding stakeholders and subsequent tools/methods that need to be mapped and integrated across all stages of a co-creation life cycle. A Life Cycle Co-Creation Process (LCCCP) for Nature-Based Solutions (NBS) was developed during this JEMES – CiSu Thesis. Using continuous improvement cycles, such as the PDCA (Plan, Do, Check and Act) cycle (KaizenTM), DMAIC (Define, Measure, Analyse, Improve and Control) cycle (Six Sigma) and, the Design Thinking methodology, the stages and sub-stages, involved stakeholders and used engagement methods in the LCCCP were identified, defined and mapped. For the stakeholders, the internal and external actors of an Urban Living Lab (ULL) were adapted to the stages and sub-stages of the LCCCP; for the engagement methods, the goals of stakeholder engagement (Mease, Erickson and Hicks, 2018) were used as a guide to select some examples of tools that could be used. The developed LCCCP comprises five stages, i.e. co-explore, co-design, co-experiment, co-implement and co-manage, creating a unique path that can be followed by practitioners for NBS co-creation.

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List of abbreviations and acronyms

BPM	Business Process Management
d.school	Hasso-Plattner Institute of Desing at Stanford
DMAIC	Define, Measure, Analise, Improve, Check
EU	European Union
ENoLL	European Network of Living Labs
GHG	Greenhouse Gas
H2020	Horizon 2020 framework
IoT	Internet of Things
LCCCP	Life Cycle Co-Creation Process
LL	Living Lab
LSP	Large-scale project
MVP	Minimum Viable Product
NBS	Nature-based solution
U4IoT	User Engagement for Large Scale Pilots in the Internet of Things
UHI	Urban Heat Island
ULL	Urban Living Lab
UN DESA	United Nations Department of Economic and Social Affairs
UNaLab	Urban Nature Labs
PDCA	Plan, Do, Check, Act
PSS	Planning support system
R&I	Research and Innovation

SDG	Sustainable Development Goal
SDST	Systemic Decision Support Tool
UCD	User-centred design
WP	Work Package

1. Introduction

Climate change has increased the need of adaptation of urban areas to hazards threatening the liveability, as well as the social and economic urban systems (van de Ven *et al.*, 2016). Threats related with changing climatic conditions such as flooding, drought, heat stress and urban heat island (UHI) effects are exacerbated due to the increase of population living in cities (UN DESA, 2017). Taking into account that more than half of the world population (54.4%) lives in urban centres and by 2030, it is expected that more than 60% of the population will live in urban areas; in the future, one in every three people will experience the direct impacts of climate change in cities (UN DESA, 2016). Being centres of development and one of the main emission sources of greenhouse gases (GHG), the future of global sustainability will be determined by how well cities implement mitigation and adaptation measures (Seto *et al.*, 2012).

Besides impacting urban regions and human population, the impacts of climate change have direct or indirect consequences for urban ecosystems, biodiversity and the environmental services they provide to the population (McPhearson *et al.*, 2018). Considering that urban ecosystems and biodiversity represent an important role in climate change adaptation and mitigation, cities must develop a system-based long-term approach with both the impacts in urban regions and human population in mind. Developing urban and peri-urban ecosystem services with a nature-based and participatory approach, can help achieve more resilient and sustainable environments for cities and urban regions (McPhearson *et al.*, 2018). In particular, nature-based solutions (NBS) are (European Commission, 2017):

> *"Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience"*

Co-creation is increasingly mentioned as the way forward with environmental related issues (Sanders and Stappers, 2008; Krogstie *et al.*, 2013; Voorberg, Bekkers and Tummers, 2015; Le Feuvre *et al.*, 2016; Russo *et al.*, 2017) , and various co-creation methods and tools have been developed and applied to this end. These methods and tools are, however, developed, described and published for specific stages of the co-creation process. It is argued that the co-creation process comprises various interlinked stages, subsequent tools/methods and corresponding stakeholders that need to be mapped and integrated across all stages of a co-creation life cycle.

Urban areas evolve and are being reshaped constantly as urbanisation advances and more inhabitants are migrating towards metropolitan areas (Bader *et al.*, 2018). Hence, *"urban planning is a continuous process of foreseeing, anticipating, and preparing for the future"* while seeking a balance amongst interest (Gencer, Folorunsho and Linkin, 2018, p. 76). Considering also that climate change is constantly generating new challenges for cities, the concept of continuous improvement and innovation measures, combining or integrating urban planning and climate change need to be taken into consideration.

The objective of this Master thesis for the Joint European Masters in Environmental Science – Cities and Sustainability (JEMES – CiSu)[1], is to identify and describe the stages, stakeholders and tools/methods of the Life Cycle Co-Creation Process of nature-based solutions for urban climate change adaptation. To this end, a document analysis and literature review was performed to have a better understanding of the different concepts involved in the JEMES – CiSu Thesis such as co-creation, NBS, life cycle approach, continuous improvement methodologies, Design Thinking, stakeholder approach and tools. From the information compiled, the proposal for the LCCCP was designed with the corresponding stages and sub-stages, as well as the stakeholders involved during each stage using the Urban Living Lab (ULL) actors. As a final step a series of tools to promote stakeholder engagement were identified. This JEMES – CiSu Thesis is expected to go beyond previous studies by providing a new approach to co-creation and, at the same time identifying the stakeholders and tools for each of the stages and sub-stages of the LCCCP.

[1] Hereafter the JEMES – CiSu Thesis.

Bradwell and Marr (2008) state that it is of absolute necessity for a successful co-creation process to have a methodology that supports its properties. A well-defined process is required in order to ensure that the aim of the process is met. This work will focus on developing a comprehensive and well-defined co-creation process that can be used to develop NBS, while understanding and enhancing the commitment and participation of the different stakeholders.

2. Project background and purpose

2.1. Living Labs

Cities are complex environments, in which different stakeholders take part and as such, they present unique challenges and opportunities for co-generation (Bader *et al.*, 2018). Today, urban settings are seen by different stakeholders as a natural space to develop ideas in a Living Lab (LL) setting (Juujärvi and Pesso, 2013). The Living Lab concept is based under the idea that innovation processes based on a co-creation approach are effective and contribute to the creation of innovations that have added value to the end-users (Krogstie *et al.*, 2013). As described by the European Network of Living Labs (ENoLL, 2018):

> *"Living Labs are defined as user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings"*

When talking about LL with a focus on more urban innovation and not only on facilitating the interaction between stakeholders, the Urban Living Lab (ULL) concept is used. It is important to highlight that LL usually have a strong focus on social value creation and civic engagement more than in commercial activities (Baccarne *et al.*, 2014).

2.2. Nature-based solutions

Urban biodiversity and ecosystems need to be safeguarded and enhanced, in order for them to deliver critical, nature-based co-benefits to promote the well-being of the inhabitants of cities. Nature-based solutions (NBS) are solutions that can help support climate change mitigation and adaptation in urban settings (Seto *et al.*, 2012).

NBS are solutions to challenges related with the society and that are entirely inspired and supported by nature. They help building resilience by being considered to be cost-effective

and to bring benefits related with the three pillars of sustainability (European Commission, 2017). The NBS concepts builds on related terms such as ecosystem approach, which advocates for an integrated management of the different ecosystem services and the living resources in a sustainable way (Faivre *et al.*, 2017). These types of solutions are designed to bring natural processes to urban settings, support economic growth and enhance overall well-being.

The Sustainable Development Goal 11 (SDG 11), promoted by the United Nations which is to *"Make cities and human settlements inclusive, safe, resilient and sustainable"* (UN, 2017) supports the idea of cities being key actors in climate change actions focusing in a sustainable future. Considering that 75% of the EU's population lives in urban areas, SDG 11 is a particular focus for the EU's Research and Innovation (R&I) NBS Agenda. There are a series of benefits associated with NBS that aligned directly with several SDG 11 targets such as temperature reduction, carbon sequestration, capture of pollutants, urban food production, among others (Raymond *et al.*, 2017). Some examples of NBS and their relations with SDG 11 can be seen in Figure 1.

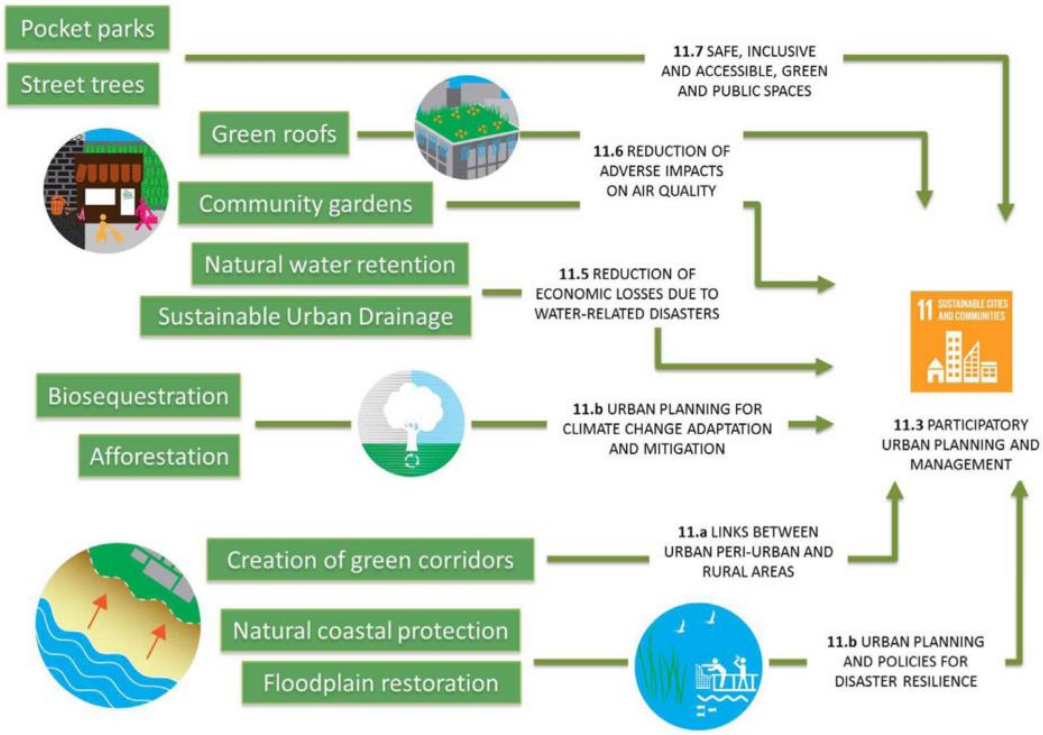

Figure 1. Potential benefits provided by a NBS in an urban environment. Source: Faivre et al., 2017

Environmental issues related with urban areas have been a subject of public debate in which is important to have knowledge provided by multiple actors in order to ensure effective interventions (Frantzeskaki and Kabisch, 2016). Being considered cost-effective solutions for climate change adaptation, NBS aim to reconnect people with nature, raise awareness of social benefits and create a demand for natural environments (European Commission, 2017). Given that the concept of ULL is based on the idea that innovation processes should be performed in a co-creative way in order to add value for their users, the ULL concept can be applied to the generation of NBS.

2.3. UNaLab – Urban Nature Labs

The EU R&I agenda for NBS uses the Horizon 2020 framework (H2020) as the financial instrument for developing the evidence base for such solutions and to assist in their adoption (Faivre *et al.*, 2017). Under the H2020, the Urban Nature Labs (UNaLab)[2] Project was born as a smart network of partner cities and organizations that aim to develop an European framework for NBS that can be implemented by cities facing challenges related with urbanization and climate change (UNaLab, 2016). The overarching objective of UNaLab is to (UNaLab, 2016):

> *"Develop, via co-creation with stakeholders and implementation of 'living lab' demonstration areas, a robust evidence base and European framework of innovative, replicable, and locally-attuned nature-based solutions to enhance the climate and water resilience of cities"*

The UNaLab Project intends to develop, pilot and prepare a new urban paradigm using large scale ULL demonstration of NBS with an ambition to achieve significant and measurable improvements in the urban environment. Those improvements are expected to enhance resilience to climate change based on effective and innovative co-created solutions and

[2] For more information, visit www.unalab.org

governance processes thanks to a strong collaboration amongst stakeholders. The overall ambition states as follows (UNaLab, 2016):

> *"UNaLab will employ innovative NBS and associated technologies to address challenges concerning city liveability, urban water management and urban ecology resulting from climate change and increased urbanisation"*

The methodological approach proposed for the UNaLab Project is a combination of design research, action research and participatory design (PADR - Participatory Action Design Research). The UNaLab Project aims for engage stakeholders in the development of the ULL and the NBS improving the conditions of the urban environment. Design Thinking and the European Awareness Scenario Workshop (EASW) were selected as the most appropriate methods to develop the co-creative innovative NBS framework for the front-runner cities which are Eindhoven in the Netherlands, Tampere in Finland and Genova in Italy (UNaLab, 2016).

2.4. Co-creation

The term co-creation was initially used by Prahalad and Ramaswamy (2000) and it's considered to be an evolution of the cooperative design used by trade unions in Scandinavia during the 1960 – 70s. Since the first term used to refer to a co-creation process, the goal has always been to describe a process in which stakeholders are engaged to be part of a problem-solving process in which they all take part as co-designers. Even though the co-creation as a concept appeared in 2000 and was used mostly to engage end users in the design of a product or service, it was fully adopted around 2010 when it was expanded to include all the stakeholders (Gioia, 2015). In Figure 2 the evolution of the term is shown.

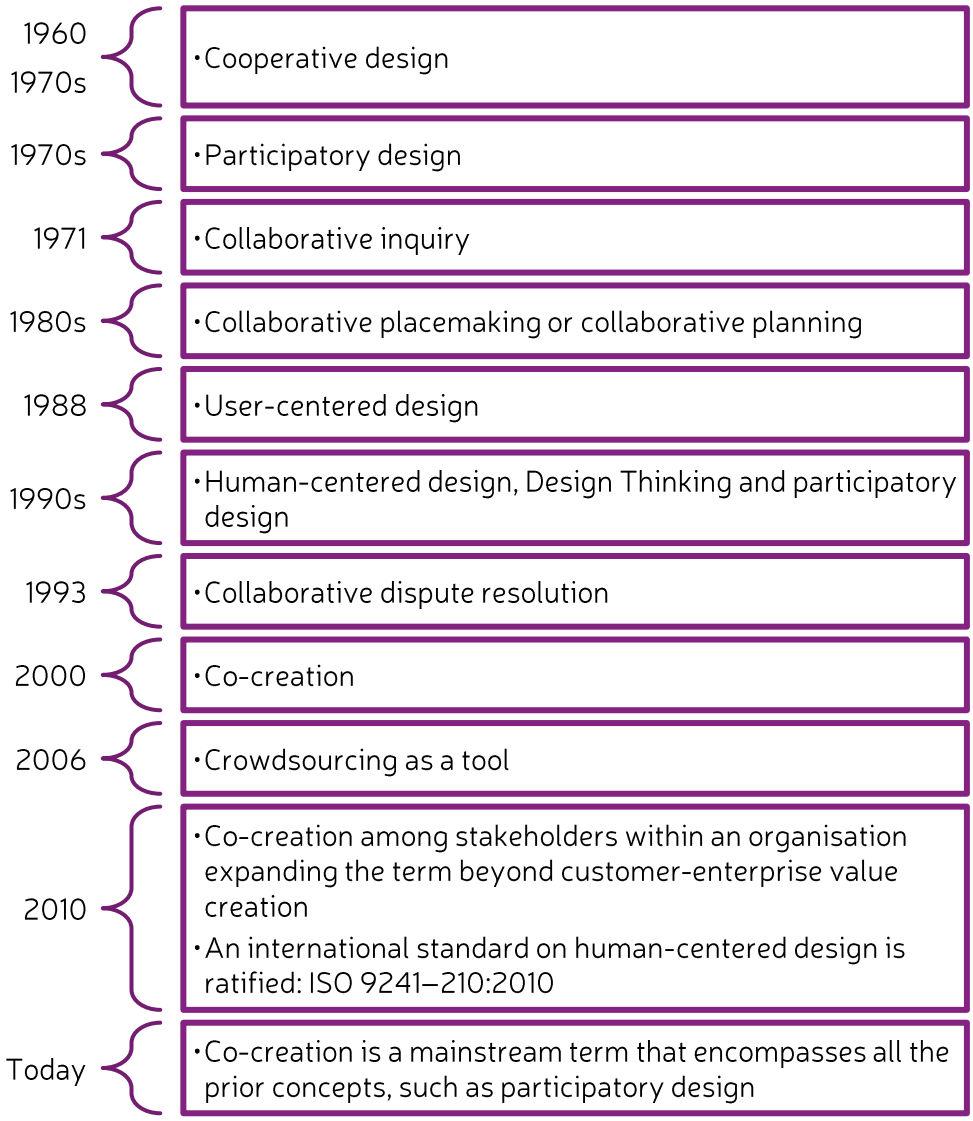

Figure 2. A brief history of co-creation. Adapted from: Gioia, 2015

The importance of co-creation in urban developments, resides in the fact that it takes place between *"economic and social actors within networks interacting and exchanging across and through networks"* (Vargo and Lusch, 2008, p. 5). This means that co-creation is more than a direct developer/customer relationship, and understands stakeholders as part of an ecosystem, and as such, understands the complex nature of relationships and the systemic interactions that take part amongst stakeholders (Pera, Occhiocupo and Clarke, 2016). Framing the development in a sense of a business ecosystem, each actor is responsible for the achievement of a solution, and as such, should take part of the decision process (Tsvetkova and Gustafsson, 2012).

Considering that all the stakeholders involved in the development of solutions related with environmental issues, are affected and affect decisions both directly and indirectly, a co-creative approach makes sense, as all of them are involved in the generation of solutions.

3. JEMES – CiSu Thesis definition

Taking into consideration that:

- a well-defined process can improve the efficiency of a project, generate more value for the stakeholders, promote a better use of resources and reduce the time needed to generate a solution; and
- a creative process is not linear but is constantly evolving.

The following research question is proposed for the JEMES – CiSu Thesis:

What are the stages of the LCCCP of NBS, who are the stakeholders that should be included during each stage according to the identified roles within a living lab, and what tools could be used during each stage of the process?

3.1. JEMES – CiSu Thesis contribution and justification

By identifying and defining the different stages of the LCCCP for NBS, the JEMES – CiSu Thesis will contribute not only to science but also to the society by providing a comprehensive framework to develop NBS in cities using a co-creative approach. The stages presented here intend to cover the complete LCCCP and are designed with a systemic and life cycle thinking approach in which the interactions of the co-creation process with different processes are taken into account. The LCCCP will be complemented with the list of stakeholders that should take part of each stage following the quadruple helix model in which government, industry academia and civil participants work to co-create solutions. The list of stakeholders and their descriptions will be based in the key stakeholders and roles defined for an ULL. As the LCCCP intends to promote stakeholder engagement, the stages will be complemented with the objective that the tools for promoting co-creation should achieve and with examples of such tools.

The involvement of different stakeholders is essential when adaptation measures are developed in existing urban areas. These stakeholders have different levels of knowledge, interests, roles and agendas in the process (Van Stigt, Driessen and Spit, 2015). A participative approach allows stakeholders to meet each other, share their knowledge, understand the problem and identify interesting adaptation measures (van de Ven *et al.*, 2016). There are some frameworks in the literature defining steps for co-creation, usually using a Design Thinking approach. These frameworks usually start after a problem has been identified and ends when a final product or services is delivered (Izvercianu, Şeran and Branea, 2014; Voorberg, Bekkers and Tummers, 2015; van de Ven *et al.*, 2016; Keeys and Huemann, 2017; Dam and Siagn, 2018a).

Environmental problems are complex, as they are usually part of a broader system and interlinked with different processes. Thus, systemic thinking approach facilitates the understanding of such complex systems and their interrelations, facilitating a global thought and avoiding simplifications (Seiffert and Loch, 2005). Applying these concepts to the co-creative approach of solving environmental problems, the process needs to be re-think in order to analyse its complete life cycle, and not only the stages that are usually covered by a co-creation process. The JEMES – CiSu Thesis intends to define the different stages of the co-creation process by using a systemic thinking approach in which the complete life cycle of the process is identified. As a complement to the LCCCP, the stakeholders that should take part of each stage will be identified, and considering that stakeholders can affect the outcome of a project (Brugha and Varvasovsky, 2000), examples of tools to promote stakeholder engagement will also be identified for the stages.

3.1.1. Identification of contribution to UNaLab

Being UNaLab a 5-year and 30-partner project, seven (7) individual work packages (WP) create the framework in which the project operates. The WP are shown in Figure 3.

Figure 3. UNaLab Project individual work packages (WP). Source: UNaLab, 2016

As WP2 relates with co-creation models and tools adapted specifically for UNaLab, the JEMES – CiSu Thesis can contribute to it as described below.

WP2 – Living Lab and Co-Creation: Models and Tools

The main goal of this WP is to develop a common ULL co-creation and demonstration framework, and identify tools, methods and techniques for the front-runner cities that can be expanded to follower cities and other cities. This WP intends to support the creation of a genuine European reference framework for LL environments. The base knowledge used for this WP are the ULL model and EASW method as general frameworks, and the hands-on experience of the front-runner cities (UNaLab, 2016).

Identified role

As part of this WP, the JEMES CiSu Project will provide a general framework for co-creation in which a city will be able to identify in which step of the LCCCP are they and follow the steps. The proposed life cycle will be of big importance mostly for cities that are still in early stages or that have never used a co-creation approach. As the most important stakeholders for each stage are identified, using the general ULL actors and roles, cities with no experience will be

able to target their stages in a more effective way, while using the proposed tools to promote a better stakeholder engagement.

3.2. Objective

General Objective

Identify and characterise the stages in the life cycle co-creation process of nature-based solutions for urban climate change adaptation, including the stakeholders and the tools that can be used to promote stakeholder engagement during each stage.

Specific Objectives

- Identify and characterise the different stages of the LCCCP
- Identify the stakeholders that participate in these stages of the LCCCP and assess how they vary over time
- Identify tools that are used during the different stages of the LCCCP, to promote a higher level of success of the activities and to make the information obtained relevant and useful

3.3. Scope and deliverables

The JEMES – CiSu Thesis will focus on the design of a pathway to be use during a co-creation process, following the concept of life cycle and considering that creative processes are not linear and should be flexible enough so they can be adapted to different types of projects. As such, the identified steps will create a general framework to be followed when a co-creative approach is to be follow when working with NBS.

The LCCCP will also have the different stakeholders that should take part of each stage of the process, according to the roles identified for ULL and examples of tools to promote the engagement of these stakeholders are also identified.

A written report and a presentation with the LCCCP, the stakeholders and the tools will be handed-in. Both will include general background of the project and the linkages to UNaLab Project.

4. Methodology

The methodology followed during the JEMES – CiSu Thesis comprises three steps, including the document analysis and literature review, the design of the LCCCP proposal and, conclusions and recommendations (see Figure 4).

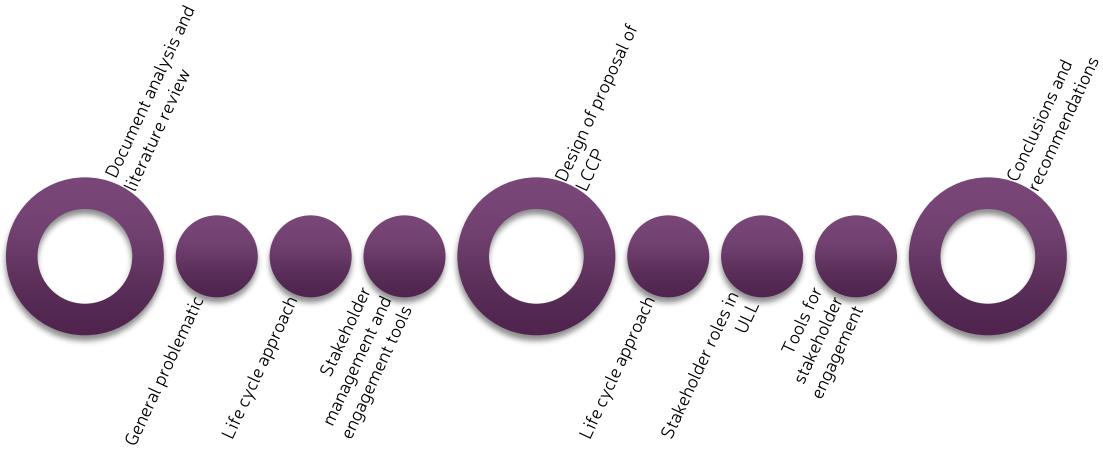

Figure 4. Methodology applied to the JEMES – CiSu Thesis.

The first step of the methodology was to perform a document analysis and literature review. A systematic approach was used during this step, in which the keywords that were used during the review were identified according to the research question and objectives of the JEMES – CiSu Thesis. Given that co-creation is the central concept of the JEMES – CiSu Thesis, understanding the evolution of the term and what it implies was important to define the different stages of the review. Considering that the UNaLab Project is set in an urban context, the initial review was made within this context. From this step, new topics to be researched were identified, such as continuous process improvement, stakeholder roles within an ULL and general objectives of tools used for stakeholder engagement. The review was divided in four (4) different topics as follows:

- General problematic – keywords: climate change, urban areas, climate extremes, co-creation, ULL and NBS

- Life cycle approach – keywords: systemic thinking, continuous improvement, Kaizen, Six Sigma, Design Thinking, co-creation framework and co-creation stages
- Stakeholders – keywords: stakeholder management and quadruple helix model
- Tools – keywords: stakeholder management, stakeholder engagement tools and methods and techniques

During the review, different combinations of keywords described above were used to narrow the search to identify papers related with co-creation in urban settings. The main databases used were Science Direct, Scopus and ProQuest, particularly for the period between 2010 and 2018 as co-creation as a methodology involving all stakeholders was developed in 2010. The reference management software Mendeley was used to compile the documents and papers used during the review.

In order to identify the relevant papers to be used during the research, two rounds of review were used. In the first-round, papers were short-listed based on title and abstracts, while in the second round short-listed papers were read and papers that did not fit within the study or were not relevant for the topic were eliminated. During this review, additional citations were identified and considered for inclusion following this same methodology. For the general problematic, the book *"Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network"* by Rosenzweig *et al.* (2018) was used. As for ULL related concepts, documents from ENoLL and UNaLab were used. Given that Kaizen™ and Six Sigma are methodologies that have international certifications by official agencies, information from these agencies was used.

The second step comprises the design of the proposal for the LCCCP, using Design Thinking and different continuous improvement methods as the base while building on information compiled during the document analysis and literature review. During the process of identifying the stages, the stakeholders involved in each of these stages were identified as the LCCCP was designed with an objective to promote stakeholder engagement during all the stages. In addition, tools to facilitate stakeholder engagement were identified and given as examples of tools that can be used during each of these stages.

Finally, after identifying and defining the three dimensions of the LCCCP (stages, stakeholders and tools), general conclusions and recommendations were derived – including limitations and critical assessment of the LCCCP designed for the JEMES – CiSu Thesis.

5. Literature review

For the three dimensions of the LCCCP to be defined, background information on a series of topics was required. Understanding the concepts of systemic thinking, life cycle approach and continuous improvement was necessary, to understand how the PDCA Cycle (Graves, 2013), DMAIC Cycle (XL Formation, 2018) and Design Thinking (Dam and Siagn, 2018a) could be used to define the stages of the LCCCP (Section 5.1). After understanding these concepts and how they can be applied to NBS, aspects of stakeholder management and participation as well as the quadruple helix approach and roles within an ULL were researched (Section 5.2) and, finally, the main goals and examples of toolkits that could be used to facilitate stakeholder engagement are presented (Section 5.3).

5.1. Life cycle approach

Environmental problems are complex and dynamic, as they are part of a broader system and are interlinked with different processes (Seiffert and Loch, 2005). Hence, solving environmental problems requires flexible and transparent decision-making processes, that are able to embrace the diversity of knowledge, understanding of the problem, values and needs (Reed, 2008).

A systemic thinking approach facilitates the understanding of complex systems or challenges and their interrelations, while allowing a global view, avoiding simplifications and developing simple interventions for transforming them (Seiffert and Loch, 2005; Bartlett and Bartlett, 2017). This approach provides a framework in which patterns can be identified allowing for the replication of processes in different scenarios in which the same patterns are identified (Bartlett and Bartlett, 2017). The life cycle approach follows the systemic thinking approach, as it considers everything and everyone involved in the product or service life cycle as well as considers all relevant impacts on the economy, environment and society (UNEP, 2004).

Processes are in continuous evolution and as such the analysis of it cannot be done with a static approach. The life cycle approach is considered to be the foundation of any consideration of improvement in a process and, hence, a framework with such characteristics

is considered important. There are several methodologies and methods that focus on improving processes, including:

- the PDCA cycle used in the Kaizen™ method that forms the basis of the cycle of continuous improvement,
- the DMAIC cycle, as an evolution of the PDCA cycle, developed by the Six Sigma methodology, and
- the Design Thinking approach for co-creation that can be compared to the methodologies and methods described above.

Continuous improvement as a methodology appeared in 1985 when the Kaizen™ method was introduced by Masaki Imai. Kaizen means change for the better (Kai=change, zen=for the better) (Kaizen Institute, 2018). This method can be seen as a formal practice and/or as a set of guidelines that, either way, is considered a method that needs to be a part of a continuous improvement culture as the core of the organisations. As part of this method the basic approach to process improvement is used, in which four steps are followed in a never-ending loop, also known as the PDCA cycle (Plan, Do, Check and Act) or Deming Wheel (Graves, 2013). See Figure 5.

Figure 5. PDCA cycle for continuous process improvement. Source: Swan, 2018.

The advantages of the PDCA cycle include promoting a simple, yet powerful approach to problem solving that, due to its iterative nature, allows for solutions to be tested and assessed

continuously. On the other hand, the cycle is considered a slow process of trial and error that might not be entirely appropriate for urgent problems or emergencies. Also, due to its nature of focusing on one problem at a time, the global view of the problem might be overlooked and, thus, the improvement might not be the most adequate when considering the whole system. Also, it is a tool that is not designed to promote creativity but, instead, to improve already existing processes and, as such, the ideas might be aligned along the same line as they have always been (Graves, 2013; MindTools, 2017; ASQ, 2018b; Swan, 2018).

As an evolution from the PDCA cycle, the Six Sigma methodology was born as a system of statistical tools and techniques that focus on eliminating defects in a process and reducing process variability. As a concept, Six Sigma follows the same steps as the PDCA cycle and adds a new one – resulting in the creation of the DMAIC cycle (Define, Measure, Analyse, Improve and Control). See Figure 6.

Figure 6. DMAIC cycle as the basis of Six Sigma methodology. Source: XL Formation, 2018

Advantages of the DMAIC cycle include a strong project and goal focus, stakeholder's engagement and *ex-ante* risk identification. Also, because it generally requires large amount of data and information, it accounts for strongly defined tools and methods. It is a methodology that requires intensive use of statistics and, as such, it allows to verify causes and solutions and, also allows for the identification of hard-to-spot problems. The heavy use of statistics can be considered one of the disadvantages of the Six Sigma methodology and the DMAIC approach, as it needs specifically trained staff to apply the methodology. Due to

the emphasis on refining and reducing variation, it also does not enable the creation of new processes (Antony, 2004; ASQ, 2018a; XL Formation, 2018).

Finally, Design Thinking also provides a framework for solving problems and *ex-ante* testing. Albeit not as structured as the methodologies and methods described above, it is defined by ULL and used by UNaLab to support the co-creation method. Considering the stages used by the Hasso-Plattner Institute of Desing at Stanford[3] (d.school, 2018), it comprises five stages (see Figure 7; Dam and Siagn, 2018) although, in some cases, they can vary from three to six stages (Design Council, 2015; Schuurman, De Marez and Ballon, 2015; KWMC, 2016).

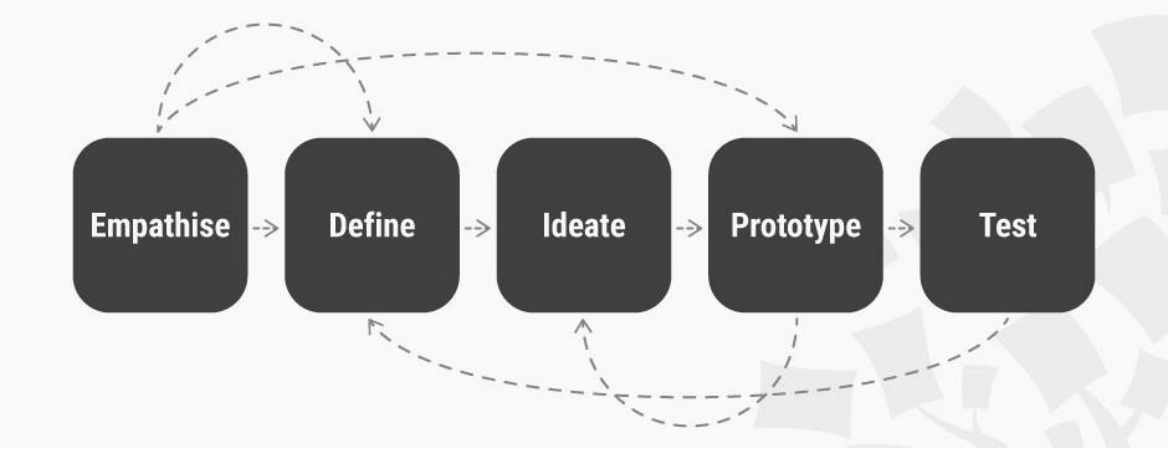

Figure 7. Design Thinking: A 5 Stage Process. Source: Dam and Siagn, 2018

One of the most recognisable advantages of Design Thinking is that it promotes creativity and thinking 'outside of the box', allowing ideas to expand and usually allowing for better and more creative ideas to rise. Design Thinking was developed with the user at its centre and supporting the decisions with collective expertise, allowing innovation by not only the designers but also the users of the solutions. The biggest disadvantage of the methodology is that it doesn't follows a strict process, relies a lot on brainstorming sessions and usually relies on qualitative evaluation. Hence, even though the selected solution might have the approval of the stakeholder, it might not be the optimal solution (Lee, 2008; Leavy, 2012; Kulkarni, Dow and Klemmer, 2014).

[3] Known as d.school

Even though methodologies and methods such as Kaizen's continuous improvement (PDCA cycle) and Six Sigma (DMAIC cycle) are very structured and rely on data to perform measurements and improvements, a parallel between them and the stages of Design Thinking can be made (see Figure 8).

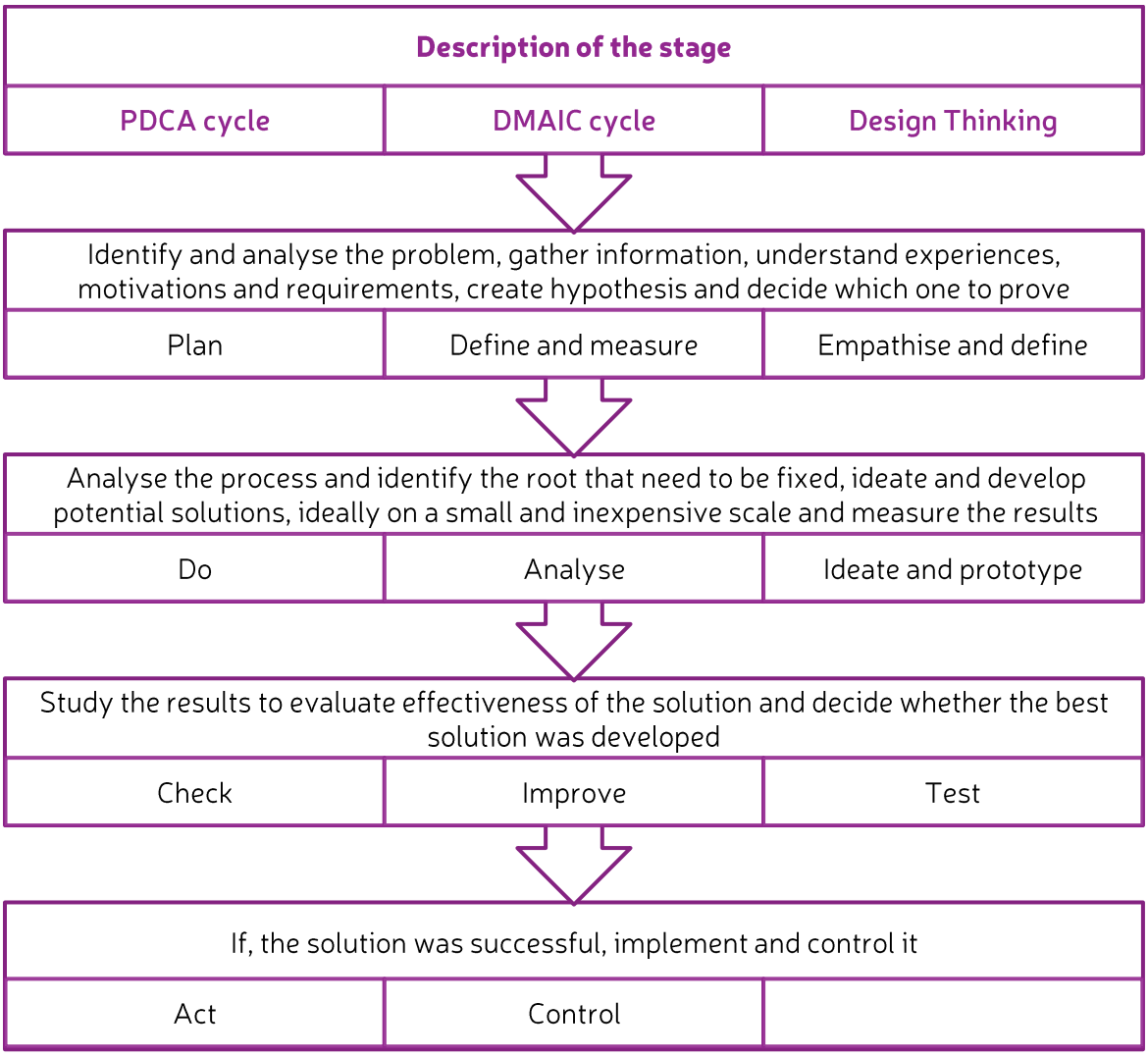

Figure 8. Comparison between PDCA, DMAIC and Design Thinking stages. Adapted from: ASQ, 2018b, 2018a; Dam and Siagn, 2018

All of the approaches, methodologies and methods described above, even though they all consider continuous improvement in a different way, start when the problem has been identified and finish when the solution is designed (as in the case of Design Thinking) or implemented (as in the PDCA and DMAIC cycles). Regardless of the constraints they have, when considering the co-creation process as more than just coming with a solution to a

problem, and considering that the cycles mentioned above (PDCA and DMAIC) are the basis of most continuous improvement processes and, Design Thinking is the basis of co-creation, they can be used as a solid base to design the LCCCP for NBS.

5.2. Stakeholders as actors in participatory processes

Climate change presents complex and dynamic challenges for cities and as such, engagement of different stakeholders is important because as a reduction in conflict, building of trust and facilitation of learning among stakeholder happens when a participatory approach to environmental issues is implemented (Reed *et al.*, 2017). For the purpose of the JEMES – CiSu Thesis, the definition of stakeholder provided by R. Edward Freeman in his text *Strategic Management: A Stakeholder Approach* (1984, p.25) is used:

> *"Any group or individual who can affect or is affected by the achievement of the firm's objectives"*

In order to ensure a legitimate participatory process, it is necessary to have a fair representation of the different stakeholders involved. When a lack of key stakeholders has been identified within a participatory process, groups who felt excluded can potentially create new conflicts or exacerbate existing ones (De Vente *et al.*, 2016). Missing stakeholders may become even more marginalised and isolated and, as such, jeopardise the level of trust amongst stakeholders (Reed and Curzon, 2015).

ULLs follow the Quadruple Helix Model (QHM) approach to define its main actors, as it clusters the protagonists of innovation-generating processes into four comprehensive categories (see Figure 9). The QHM is an extension of the Triple Helix Model (THM) and was first defined by Carayannis and Campbell (2011) in order to represent the civil society and how they are invited to participate in knowledge and innovation creation. Both models refer to structures in which innovation is stimulated by co-creation amongst the actors, in which knowledge moves without any restriction (García-Terán and Skoglund, 2018).

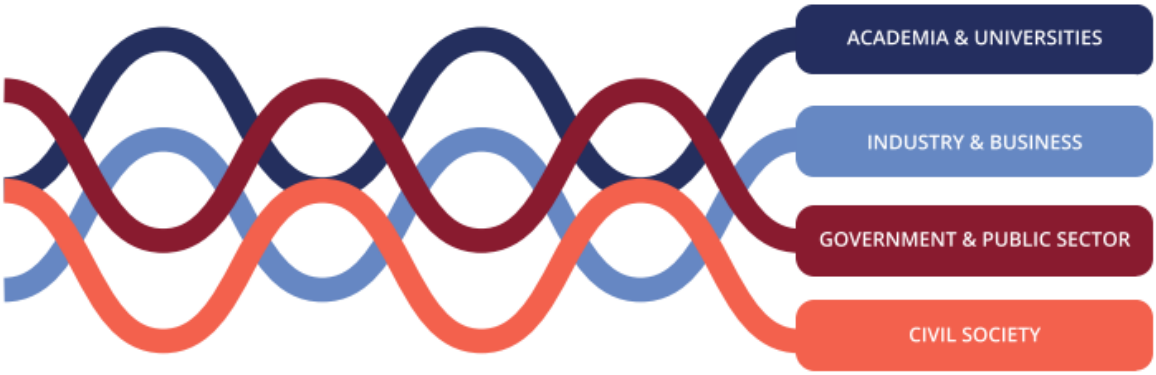

Figure 9. The Quadruple Helix Model (QHM). Source: Finquelievich (2016)

As defined by Cavallini *et al.* (2016, p. 5) both the THM and QHM are *"grounded on the idea that innovation is the outcome of an interactive process involving different spheres of actors, each contributing according to its 'institutional' function in society"*. The four categories are described as follows (Cavallini *et al.*, 2016; Finquelievich, 2016) and the actors of the categories are shown in Figure 10:

1. **Academia and universities.** Historically this sector has always been fundamental in knowledge production and has only recently become a contributor to innovation thanks the crucial role that knowledge has gained in development processes. This sector has become a key actor of economic and cultural growth.

2. **Industry and Business.** Also known as the commercial market as the economic category. Frequently a strong actor that leads technological and organizational innovation and usually has the role of generating, producing and distributing products and services. Produces innovations alone or associated with other stakeholders.

3. **Government and public sector.** The innovation within this sector is framed within new ideas that create value for the society and as such usually this innovation comes through policies, strategies and initiatives. The role of these institutions is to support both industry and academia for the application of information to development.

4. **Civil society.** Represents citizens or users who provide knowledge about their needs, experiences and expectations. As they are directly affected by any changes made in

an urban context, they can provide first-hand information related with the problem that is the subject of the study, becoming innovation users. By including civil society to the THM, thus creating the QHM, the innovation shifts from technical to social.

Figure 10. Quadruple Helix Model (QHM) stakeholder's categories. Source: Finquelievich (2016)

Besides the categories used for the QHM, a series of specific roles within an ULL are described by Ståhlbröst, Bergvall-Kareborn and Eriksson (2015) and used within the UNaLab Project. These roles are described as either internal (see Figure 11) or external (see Figure 12).

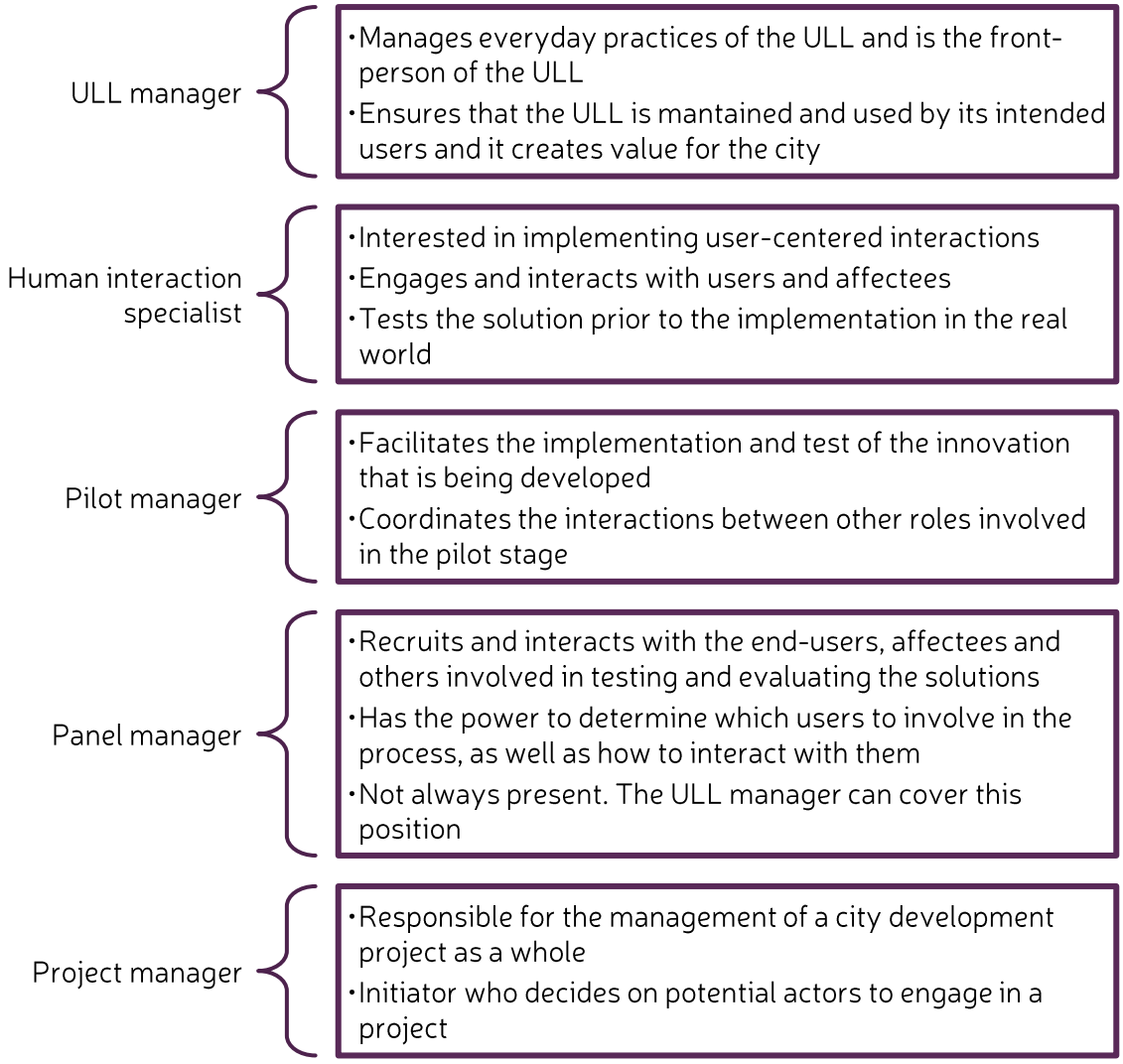

Figure 11. Internal roles of key stakeholders in an ULL. Adapted from: Ståhlbröst, Bergvall-Kareborn and Eriksson (2015)

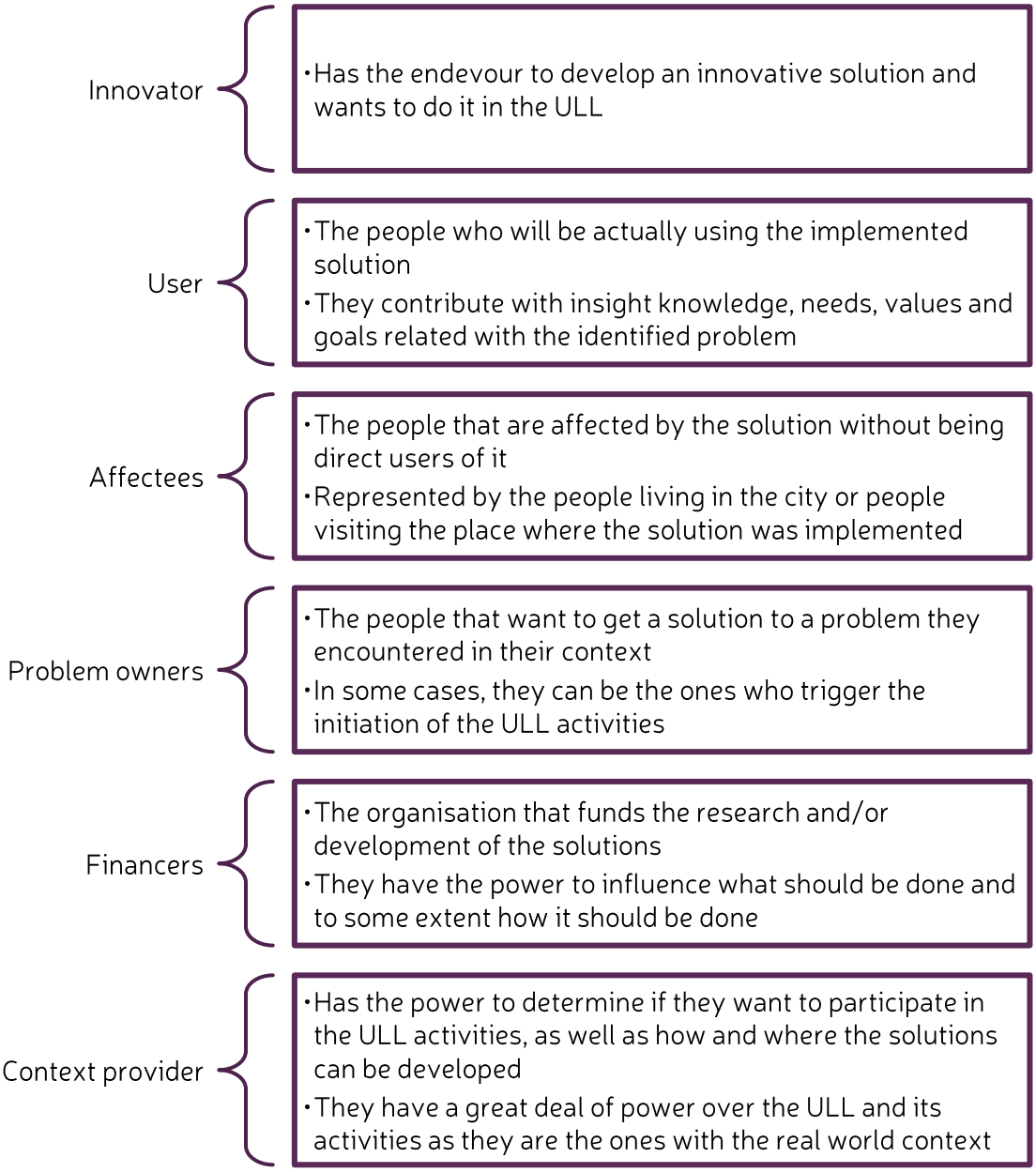

Figure 12. External roles of key stakeholders in an ULL. Adapted from: Ståhlbröst, Bergvall-Kareborn and Eriksson (2015)

For the purpose of the JEMES – CiSu Thesis, the specific internal and external roles of some stakeholders in an ULL will be taken into account when identifying which stakeholders should take part of each stage.

5.3. Stakeholder engagement tools

The challenges for cities and its inhabitants that arise due to climate change are complex and dynamic. It has been claimed that a participatory approach in which different stakeholders are engaged, can have an important effect on reducing conflict, building trust and facilitating learning amongst stakeholders when dealing with environmental challenges (Reed *et al.*, 2017). It is also important to mention that when stakeholder engagement fails, pre-existing conflicts can be inflamed and could potentially escalate into distrust and alienation amongst stakeholder groups (Emery, Mulder and Frewer, 2015).

A participatory and multiple-stakeholder engagement approach is being recognised as the basis for urban processes, understanding that an iterative shared-learning dialogue can expand the ideas and perspectives of city managers and project developers (ACCCRN, 2009). In business management and policy research, it has been recognised that stakeholders can affect the success of a project (Brugha and Varvasovsky, 2000), and understanding the nature of a stakeholder's stake in a project and its outcomes is necessary for an adequate engagement process. The stakes could be either of interest, legal or moral right, ownership, knowledge or contribution (Bourne, 2016).

As defined by Bourne (2016, p. 432) engagement can be defined as

> *"the various communication practices, processes and actions that an organization (or project team) must perform to involve stakeholders to secure their involvement and commitment, or reduce their indifference or hostility"*

Even though stakeholders, according to the definition given above, are aware of the project, its outcomes and are prepared to be involved in it, effective identification, analysis and representation of the different stakeholders is crucial to ensure the success of the project (Reed and Curzon, 2015). The involvement of different stakeholders allows to explore issues, concerns and management measures from different points of view and as such gather different perspectives and information due to the diversity in knowledge and experiences. In

theory, involving a wide range of stakeholders results in decisions that are more equitable, socially-relevant and ecologically-sound (Mease, Erickson and Hicks, 2018).

Involving key stakeholders during the early stages of a participatory process has proven to be of great importance for obtaining a positive outcome (Reed *et al.*, 2009; Mease, Erickson and Hicks, 2018). Thus, engagement must capture relevant knowledge throughout the duration of the project and amongst stakeholders, reflecting the needs of the communities and understanding that they can vary over time (Reed, 2008). Considering that stakeholder engagement is usually a complicated and messy process, tainted with conflict, disagreement and diverging points of view (Mease, Erickson and Hicks, 2018), the goals of the engagement process should be clear from the beginning in order. The most common goals are shown in Figure 13.

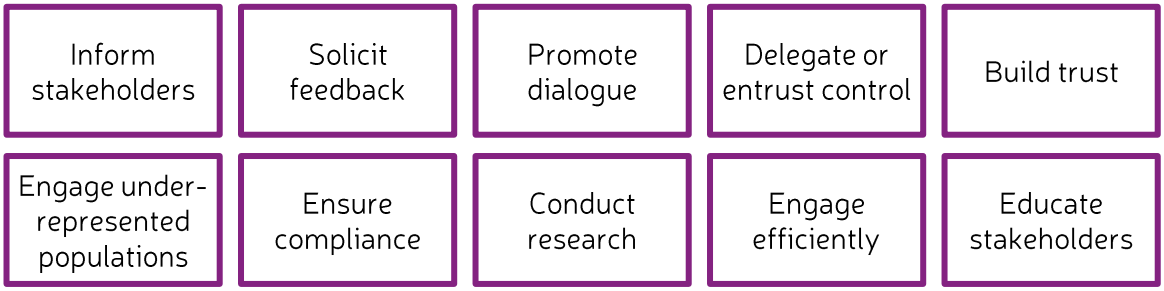

Figure 13. Management goals for stakeholder engagement. Adapted from: Mease, Erickson and Hicks (2018)

To promote the engagement of the stakeholders and to achieve the management goals mentioned above, different strategies and tools have been designed and implemented specifically for participatory processes. A robust toolbox of stakeholder strategies can help managers to design effective approaches. These tools should be defined and structured in a way that allows managers to plan, implement, reflect and evaluate the decisions made by the stakeholders (Mease, Erickson and Hicks, 2018). Participatory and user-centred methodologies, such as Design Thinking and co-creation, provide a framework for tools to be designed and focused on stakeholder engagement (van de Ven *et al.*, 2016).

There are many co-creation stakeholder engagement tools around. For example, the toolkit developed for the U4IoT project (U4IoT, 2018c), the MindTools webpage (MindTools, 2018) and the Service Design Tools webpage (Tassi, 2009b)

The end-user engagement toolkit developed for the H2020 project U4IoT[4] (User Engagement for Large Scale Pilots in the Internet of Things) offers a series of tools and support services adapted for the IoT (Internet of Things) community in the large-scale pilot (LSP) projects (U4IoT, 2018c). The available tools are divided into three different phases that are part of the innovation process and further divided into iterations as part of the phases (U4IoT, 2018a). The toolkit also offers an Interactive Flow Diagram that recommends the user which tools to use according to a series of question that help determine the stage of the process, objective, type of data, sample size, resources and level of expertise (U4IoT, 2018b).

The MindTools webpage[5] offers skill-building resources and includes a very comprehensive and varied toolkit. The toolkit is divided into 12 categories and besides describing the tools, it explains how it can be used, provides templates, personalised trainings, books and interviews. The webpage comes with a basic search engine by keyword and the results are identified to the category to which they are part and also offers a membership that allows full access to the website and the tools (MindTools, 2018).

The Service Design Tools webpage[6] is *"an open collection of communication tools used in design processes that deal with complex systems"* (Tassi, 2009b). The available tools are divided into when are they used, the information they produce, who are they addressed to and the what type of project they can cover. Besides offering a description of the tool and references, it offers case studies and shows which tools from the toolkit are related.

In the context of the UNaLab Project, a co-creation toolkit is under development. The aim of the toolkit is to support the development of ULL for co-creation and experimentation of NBS, as well as collect methods, tools and techniques for stakeholder engagement. The toolkit is divided into the different stages of the co-creation process and will include a description of the tool, as well as results, relevant figures and links (UNaLab, 2016).

[4] For more information, visit https://u4iot.eu/end-user-engagement-toolkit
[5] For more information, visit https://www.mindtools.com/
[6] For more information, visit http://www.servicedesigntools.org

6. Co-creation path

This section describes the life cycle co-creation process of nature-based solutions for urban climate change adaptation, including the various stages, the stakeholders involved during the stages and some examples of tools that could promote stakeholder engagement during the co-creation process. Section 6.1 explains how the co-creation path was conceptualised using the stages, actors and tools as components. The developed co-creation path was inspired by the PDCA and DMAIC Cycles, and the Design Thinking methodology (see Section 5.1), with the main stages and sub-stages presented and described in Section 6.2. Considering the specific roles identified for ULL, Section 6.3 identifies the stakeholders that should take part during the stages and sub-stages presented in the co-creation path. Finally, Section 6.4 describes the general objective that tools for stakeholder engagement should have for each of the main stages and presents a series of examples taken from the UNaLab and partners experience.

6.1. Conceptualization of the LCCCP

Business Process Management (BPM) is a framework that provides the guidelines for organisations to optimise their performance. Thus, BPM is a systematic approach to process improvement (Van Der Aalst, La Rosa and Santoro, 2016). Even though this JEMES – CiSu Thesis is not focusing on process improvement, some of the concepts of BPM can be used to frame the co-creation life cycle in a more comprehensive way. BPM relies on the identification of processes with their different components, going from a broad view of the organisation, relying on a systemic thinking approach, to the definition of the tasks of each process (Van Der Aalst, La Rosa and Santoro, 2016).

First, using BPM as an inspiration and considering co-creation as a macroprocess, stages and sub-stages in co-creation are identified. The stages are designed to give a general guide for the co-creation process while the sub-stages provide more detail into each of the stages. The stages and sub-stages were identified and described using the PDCA and DMAIC Cycles as well as the Design Thinking methodology (as described in Section 5.1) as the main inspiration. The stages and sub-stages are presented and described in Section 6.2.

Secondly, the actors to be engaged at each stage were identified after reviewing the QHM and the actors of ULL, considering both the internal and external actors (as described in Section 5.2). The descriptions made by Ståhlbröst, Bergvall-Kareborn and Eriksson (2015), were used to identify the stakeholders which should participate in specific stages (see Section 6.3).

Finally, using the most common goals of stakeholder engagement described by Mease, Erickson and Hicks (2018) and shown in Figure 13 (see Section 5.3), examples of tools to promote said engagement were identified. The main goals of the tools were identified and examples were given (see Section 6.4).

The three parts mentioned above, form the skeleton of the co-creation path. The stages represent the road for co-creation while the specific stakeholders and tools, support the objectives of each of these stages. Figure 14 shows a new conceptual integration of the three components designed through the JEMES – CiSu Thesis.

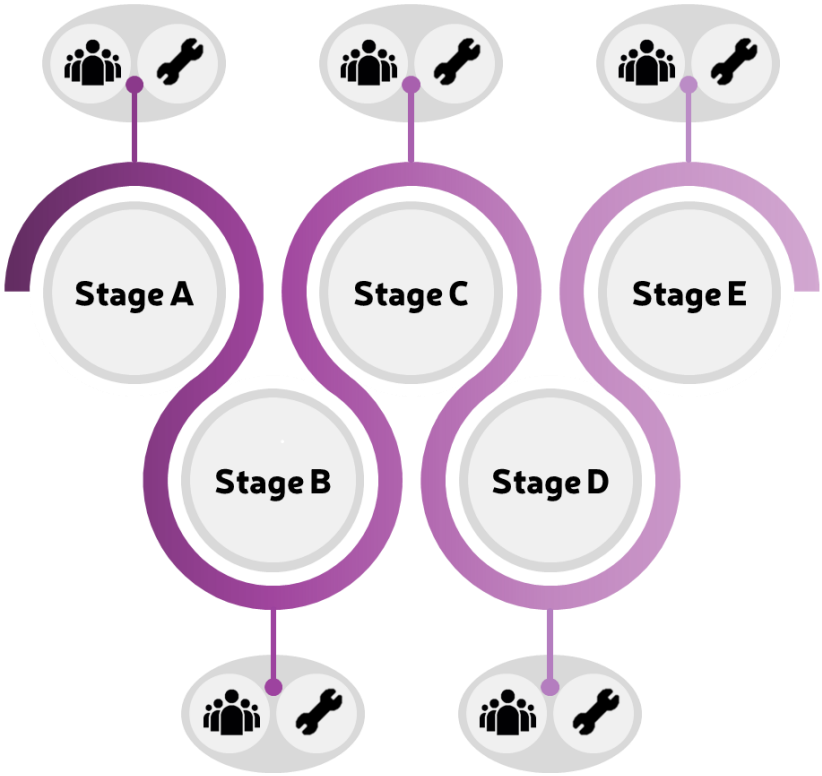

Figure 14. Conceptual integration of LCCCP stages, actors and tools

6.2. Co-creation life cycle

The LCCCP consists of five (5) stages and a series of specific sub-stages. The first stage, CoExplore, represents the initial steps taken prior to ideating a solution with the stakeholders. The second stage, CoDesign covers the complete process of the potential solution(s) ideation process until the prototypes design. The CoDesign stage is complemented by the third stage, CoExperiment in which the prototypes are tested and feedback information is sent to the CoDesign phase until the most accurate solution is identified. The fourth stage, CoImplement describes the process of implementation of the solutions. Finally, the fifth stage, CoGovernance, represents what happens after the solution is implemented and covers the maintenance and governance of the solutions. Figure 15 shows the LCCCP with the stages and sub-stages.

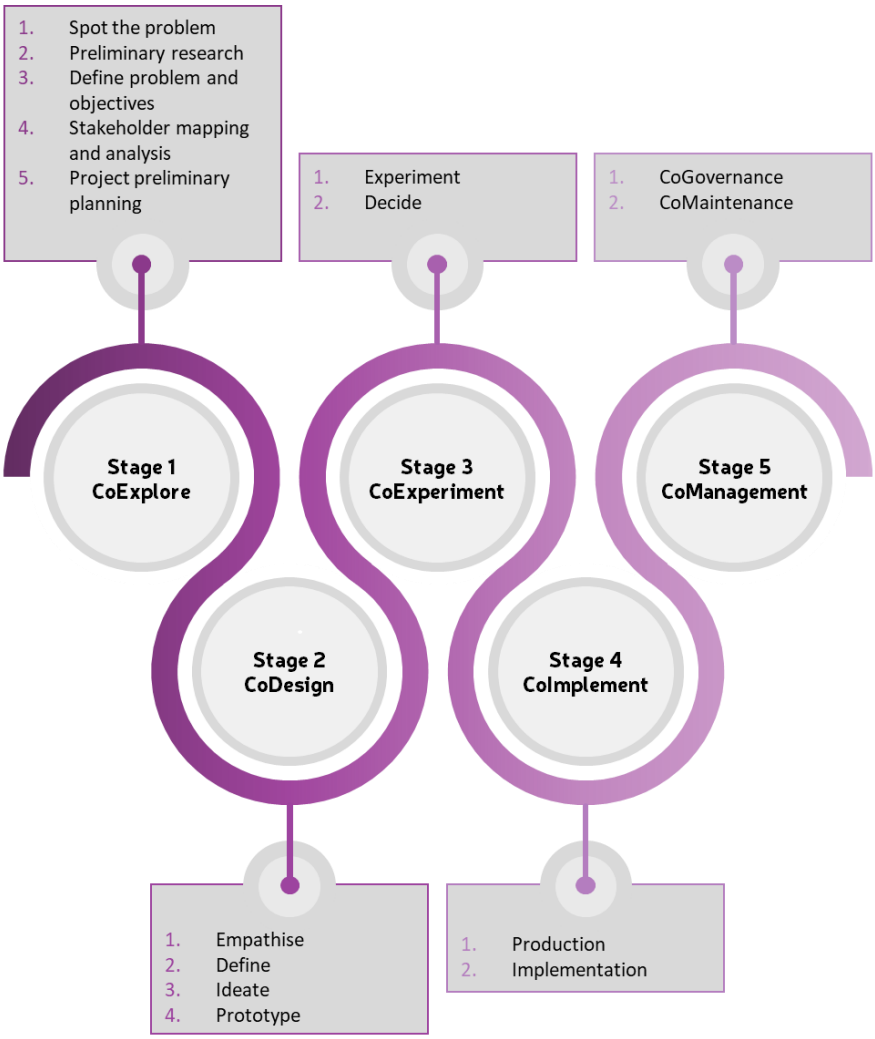

Figure 15. LCCCP with stages and sub-stages

Stage 1: Initiative – CoExplore

This phase represents the beginning of the LCCCP and, as such it covers all the preparatory stages needed to create and implement solutions. It is mostly inspired by the **Plan** step of the PDCA Cycle and the **Define** step of the DMAIC Cycle. This stage begins when one of the stakeholders of the project spots a problem and ends when the mapping and analysis of the stakeholders that will take part of the process is completed and, the preliminary planning of the project is done . The CoExplore stage will provide all the information needed to create a solid foundation for the process, including information related specifically to the problem and information on the stakeholders. The main purpose of this stage is to identify and analyse the problem, gather initial information and create hypothesis. It also covers the identification and selection of stakeholders, and thus it will also allow for information such as experiences, motivations and requirements to be gathered. The sub-stages that are part of the CoExplore stage are the following:

1. **Spot the problem.** This sub-stage represents the beginning of the process and as such is considered the trigger of the co-creation process. During this stage the current or emerging problem(s) are identified by any of the stakeholders – be it through structured research or identified by chance. An example of a problem identified by chance is when a citizen feels that the city centre is much hotter than the rest of the city (heat island effect). During this stage a general approach is made and the consequences or causes are not analysed. It is important to reach a consensus across the stakeholders considering what is the main problem or problems that need to be solved. For this stage, any information available is used to understand the context of the problem(s). The questions that need to be answered during this sub-stage are (ATAP, 2016a):
    a. What is the current problem?
    b. What is the future problem?
2. **Preliminary research.** After spotting the problem(s) and agreeing on which one is the main one, a preliminary research needs to be done. Data-rich evidence on the problem is collected, including characteristics, scale and extent, cause and effect, and all

associated costs (economic, social and environmental). The objective of this sub-stage is to demonstrate that the problem(s) creates constraints for achieving stated goals and objectives at the local, regional or global level. During this sub-stage, additional problems might be identified. The following questions can provide guidance during this stage (ATAP, 2016a):

a. How is the problem preventing the achievement of the objectives?

b. Can the effects of the problem be measured?

c. What are the drivers that influence the problem?

d. How will the drivers of the problem change over time?

e. Will the problem increase gradually or will there be a step change increase?

f. What are the symptoms of the problem?

g. What are the causes of the problem?

h. Are there dependencies between this problem and others?

i. Are there any other initiatives under development that influence the problem?

3. **Define problem and objectives.** After having a comprehensive understanding of the problem(s) that will enable effective action, the problems need to be prioritized and correctly defined. The following questions can be used for prioritizing (ATAP, 2016a):

a. Which problem presents the greatest obstacle to achieving the goals and objectives?

b. Which problem prevents the most important objective from being achieved?

After identifying the problem(s) that will be tackled with a participatory planning approach, the problem(s) needs to be described in a comprehensive way. For this, a design brief can be used, in which a general and simple description of the problem(s) should be stated. This brief will work as an initial roadmap and means of communicating between the stakeholders, and it shouldn't be seen as a static

document as it can be modified during the project. For this brief, questions such as the following could be used (Tran, 2015):

a. What's the purpose?

b. Why are we doing this now?

c. Are we going down the right path?

d. Who are we serving?

e. What are our initial success metrics?

4. **Stakeholder mapping and analysis.** During this sub-stage, the main objective is to identify the actors of the project. This sub-stage will allow to understand stakeholders, their background, thoughts, beliefs, expectations and relations, with the aim to facilitate and enhance the co-creation process. For this stage, the QHM and the internal and external roles of an ULL must be taken into consideration (see Section 5.2)

5. **Project preliminary planning.** The last part of the CoExplore stage, is the preliminary project planning. This sub-stage sets the context for all subsequent steps of the LCCCP. During this sub-stage, the targets and performance indicators are identified, as well as the principal milestones to be met during the project. The main output of this sub-stage is the roadmap to follow during the projects, with the main actors of each milestone and task identified. The preliminary planning should be available for all the stakeholders and should clearly state the objectives and expected results. Questions such as the following can help create the preliminary planning (Andrews, 2017):

a. What's the real problem we're trying to solve?

b. What are our objectives, and how will solving this problem help achieve those objectives?

c. Who is our current target audience and ideal audience? Are there multiple audience segments?

d. Who are our stakeholders and how do we expect them to take part of the project?

e. What are the strengths and weaknesses of our current system?

f. What are our other constraints, such as timeline and budget?

g. How will success be measured?

Stage 2: Create – CoDesign

This stage is mostly based on the Design Thinking methodology. It allows for stakeholders to identify solutions together and, at the end create prototypes of the solutions to be tested later in the process. It starts with empathising with the involved actors in order to understand the actual needs and wishes. After identifying what the actors would like as solutions, a deeper analysis of the information needs to be obtained, to understand the primary problem or pain points actors have. The pain point identification will allow for a better solution design, which is done during the ideation sub-stage. To finalise this stage, the prototypes of the solutions are built. This sub-stage receives constant feedback from the CoExperiment stage until the most desirable solution is identified and accepted by the stakeholders. The sub-stages that are part of this stage are the following:

1. **Empathise.** This sub-stage allows to see the problem and potential solutions through other people's eyes and as such, it allows for a deeper understanding of the underlying motivations of stakeholders. It is important to not only understand the physical needs of the stakeholders, but also the psychological needs as well. This sub-stage will allow the designers, developers and/or planners to set aside their own assumptions about the world and their needs in order to gain insight into the users and their needs (Dam and Siagn, 2018b).

2. **Define.** During this sub-stage, all the insight gained during the empathizing process is put together and analysed. The main objective of this stage is to synthesize the information gathered and define the core problems that have been identified so far. Understanding how the actors feel about the current solution and why they think they need a new and/or improved can help set the framework for the following steps (Dam

and Siang, 2017a). Questions such as the following can help defining the core problems (Andrews, 2017):

a. What's the problem or pain point the user is experiencing?

b. What products and/or solutions do they currently use to solve that problem or pain point?

c. What are the shortcomings of their current solution?

d. How will the new/improved solution be better?

e. What featured should be prioritised in the new/improved solution, and which might be added later?

3. **Ideate.** The core task to be performed during this sub-stage is the idea generation. For this sub-stage to be a success, the information gathered in the previous steps is essential as it provides the input to generate potential successful solutions. This sub-stage intends to step outside of the obvious solutions and increase the innovative potential of the solution, while bringing together perspectives and strengths of different stakeholders. During this sub-stage a divergent approach to ideation is used, in which as many ideas as possible are considered (Dam and Siang, 2017b).

4. **Prototype.** The objective of this sub-stage is to converge over the solutions obtained during the Ideate sub-stage. A conscious evaluation of the ideas is performed in order to identify which solutions best align with the objectives. When the most suitable ideas are identified, inexpensive prototypes are created for further testing. Prototyping allows to test hypothesis and potential solutions without spending a lot of time, money and resources (Dam and Siang, 2017c). This sub-stage helps finding an answer to vital questions such as the following (Andrews, 2017):

a. Are we sure we're solving the right problem?

b. How will our idea meet our users' needs and relieve their pains?

c. Is our solution technically feasible?

Stage 3: Evaluate – CoExperiment

The CoExperiment stage allows to study the results, evaluate effectiveness of the solution and decide whether the best solution was developed. This stage gives continuous feedback to the CoDesign stage in order to fine tune the solutions and reach the most adequate one. It consists of two sub-stages, the first one covering the experimentation in which the prototypes created in the last sub-stage of the CoDesign phase are tested; the second one covers the decision itself, of whether the solution tested is the best one or, if it needs to be discarded or improved. The iterations between CoDesign and CoExperiment can be as many as needed in order to reach the most adequate solution for the identified problem.

1. **Experiment.** This sub-stage centres in usability test as it is about sharing the prototype with real users to receive their feedback. Besides receiving feedback, this sub-stage also provides a deeper understanding of the users, as they could potentially express desires or preoccupation that differ from the already identified ones. It allows to empathise even more with users. The results of this stage might lead to new information that change the way the problem was defined during the Define sub-stage, it might generate new solutions in the Ideate sub-stage and lead to a new iteration of the Prototype sub-stage (Dam and Siang, 2017d).

2. **Decide.** This sub-stage complements the Experiment sub-stage, as it occurs when a decision over the prototype is made. For this stage the information about the objectives, constraints, needs and wishes would need to be clear in order for the design team to make the decision about which of the tested prototypes represents the most adequate solution. Given the case that the most adequate solution is not yet identified, feedback is sent to the CoDesign stage in order to begin a new iteration. The following questions will provide the necessary information to decide over the tested prototype:

    a. Does the solution work as intended?

    b. Does it solve our users' primary problems and pain points?

    c. How could it be improved?

Stage 4: Implement – CoImplement

After identifying the most adequate solution(s), this stage roughly covers the implementation. The production and implementation of solutions is very variable depending on the solution itself and, as such, only a general description of the sub-stages is given as part of the JEMES – CiSu Thesis. This stage covers the management of the planned solution and its overall budget. Major activities involved in this stage are the detailed planning and design of the solutions, commissioning, risk management and the final delivery of the solution (ATAP, 2016b). The general sub-stages are:

1. **Production.** This sub-stage covers the production of the solution(s) and overall control of the budget. The major activities that comprise this stage are the following (ATAP, 2016b):
    a. Detailed planning and design of initiatives
    b. Construction (for infrastructure initiatives) and commissioning
    c. Risk management relevant to these activities
    d. Delivery on time, within budget and to agreed quality specifications
2. **Implementation.** After the solution(s) is delivered, its implementation needs to take place. This means putting the stakeholders together in order to hand-in the solution(s), explain it and share information about how it can be maintained and why the solution(s) is the most adequate to solve the initial problem. This stage is crucial as it will set the ground for future implementations and build trust.

Stage 5: Control – CoManagement

After the solution(s) are implemented, the control stage starts, in which a defined governance structure must be defined and put in place. The maintenance of the solution(s) must also be taken into account, as it might rely too much on a couple of stakeholders and, as such, end-up being forgotten.

1. **CoGovernance.** For this sub-stage, a clear governance structure must be defined and shared with all the stakeholders. Considering that the process performed using a

participatory approach, it is important to understand that the governance, or co-governance, of the solutions must continue along the same line. Co-governance implies that the decisions are made at the lowest levels possible, recognising that the power of deciding of each member is equitable. As stated Dodson (2014, p. 64) *"rather than viewing [collaborative and co-governance arrangements] as 'solutions to problems' we must view these arrangements as a starting point for [new or restored] relationships, which will continue to evolve as time passes"*. The following should be taken into account when setting-up a co-governance arrangement (ATAP, 2016b):

a. New requirements for local government(s) to regularly review arrangements for delivering services

b. Public expectations of increased participation and access to decision makers

c. The increase in and complexity of *"wicked problems"* requiring innovative solutions

2. **CoMaintenance.** Related with the concept of co-ownership, for the solution(s) that was implemented, it needs to be defined who will be the owner(s) of it. Some of the responsibility must rest on the end users as they should take part in the co-ownership of the solution(s) given that they are the ones directly affected by it. The challenge of this sub-stage is to make stakeholders believe that they take part in the ownership of the solution(s) and, as such, should also take part in the maintenance of it (Prizeman, 2016).

Good and open communication during the entire project is crucial in order to maintain and support the motivation of the stakeholders. All stakeholders should be able to provide inputs on a formal as well as an informal basis. Given that there are a lot of communication tools that vary in reach and complexity (e.g. teleconference, email, files sharing, website, newsletter, social media, phone calls, events, mobile apps), the communication channels should be adjusted according to the relevance, closeness and technological capacity of the stakeholders (Russo *et al.*, 2017).

Engaging stakeholders, including the community, during co-creation processes can lead to a more comprehensive process. It could provide insights in problems that were not identified previously or shed a new light on known problems. A planning or developing process that does not engage with stakeholders could risk identifying and tackling only the best known or most acute problems without a broader strategic context (Reed, 2008; Reed *et al.*, 2009; ATAP, 2016a; Russo *et al.*, 2017)

6.3. Stakeholders per stage and sub-stage

This section refers to the stakeholders or actors that should at least be included during each of the stages and sub-stages mentioned above. It should not be taken as a definitive list but as a guide as they could vary considerably according to the project and if it is done with public or private institutions, or if it is done with public-private partnerships. The summary of findings regarding internal and external actors of ULL performed by Ståhlbröst, Bergvall-Kareborn and Eriksson (2015) is used as a base for the definition of the actors. The stakeholders proposed to be included at each stage and sub-stage are shown from Figure 16 to Figure 20.

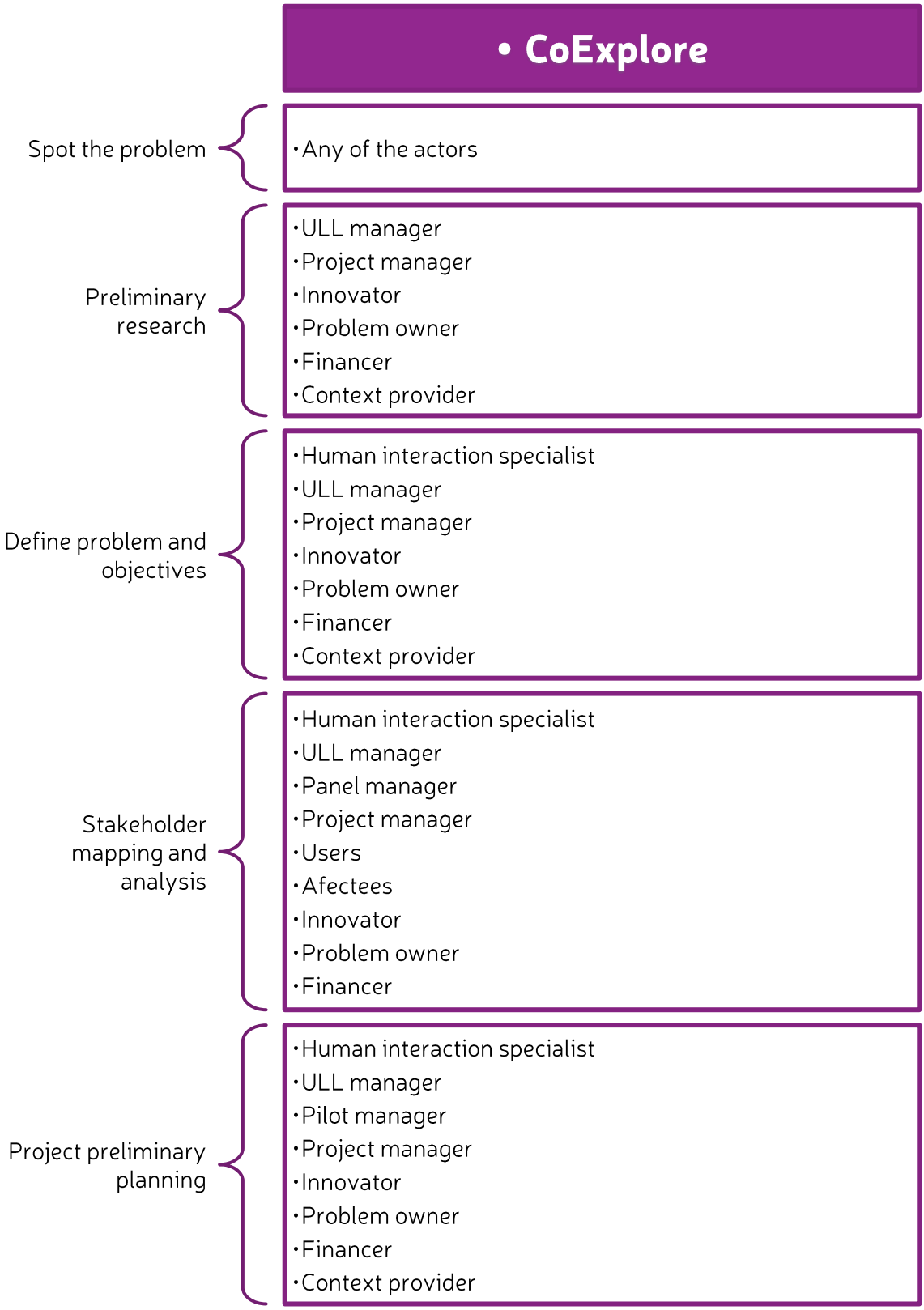

Figure 16. Stakeholders of the CoExplore stage of the LCCCP. Adapted from Ståhlbröst, Bergvall-Kareborn and Eriksson (2015)

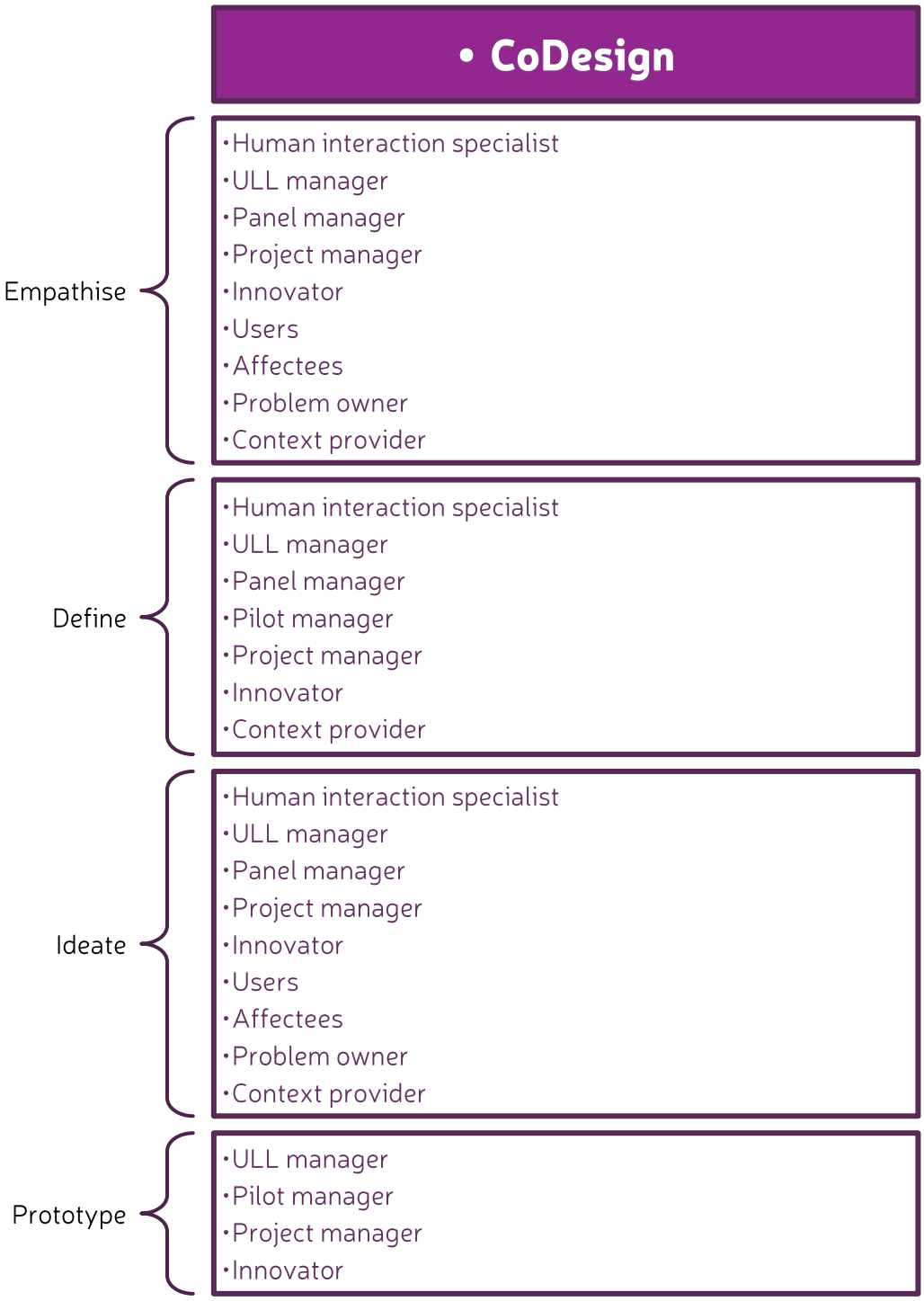

Figure 17. Stakeholders of the CoDesign stage of the LCCCP. Adapted from Ståhlbröst, Bergvall-Kareborn and Eriksson (2015)

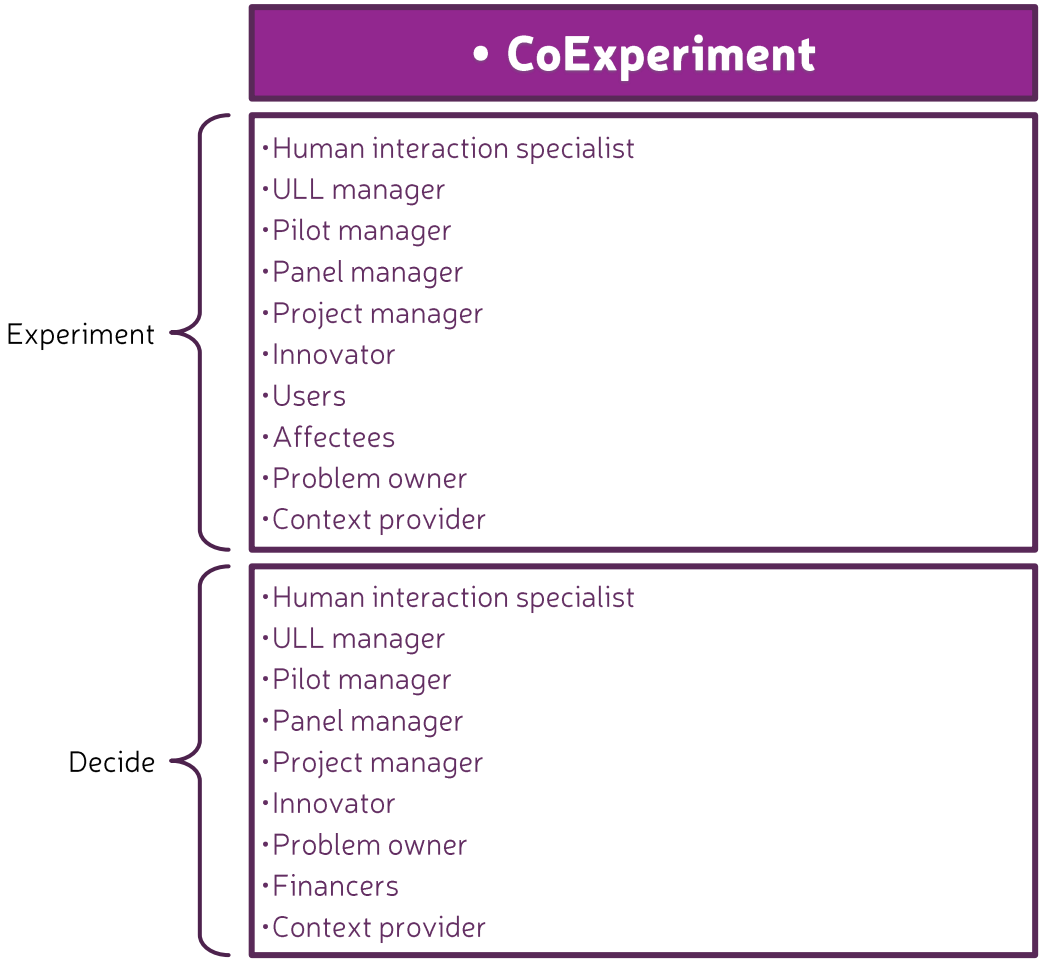

Figure 18. Stakeholders of the CoExperiment stage of the LCCCP. Adapted from Ståhlbröst, Bergvall-Kareborn and Eriksson (2015)

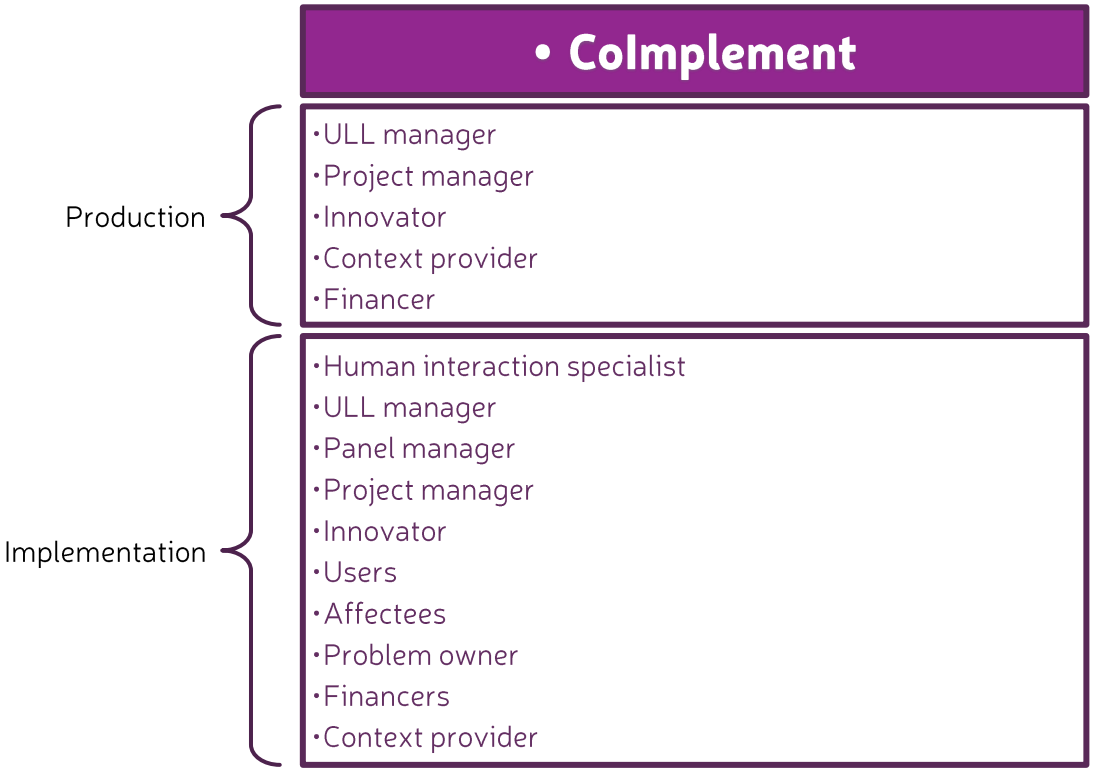

Figure 19. Stakeholders of the CoImplement stage of the LCCCP. Adapted from Ståhlbröst, Bergvall-Kareborn and Eriksson (2015)

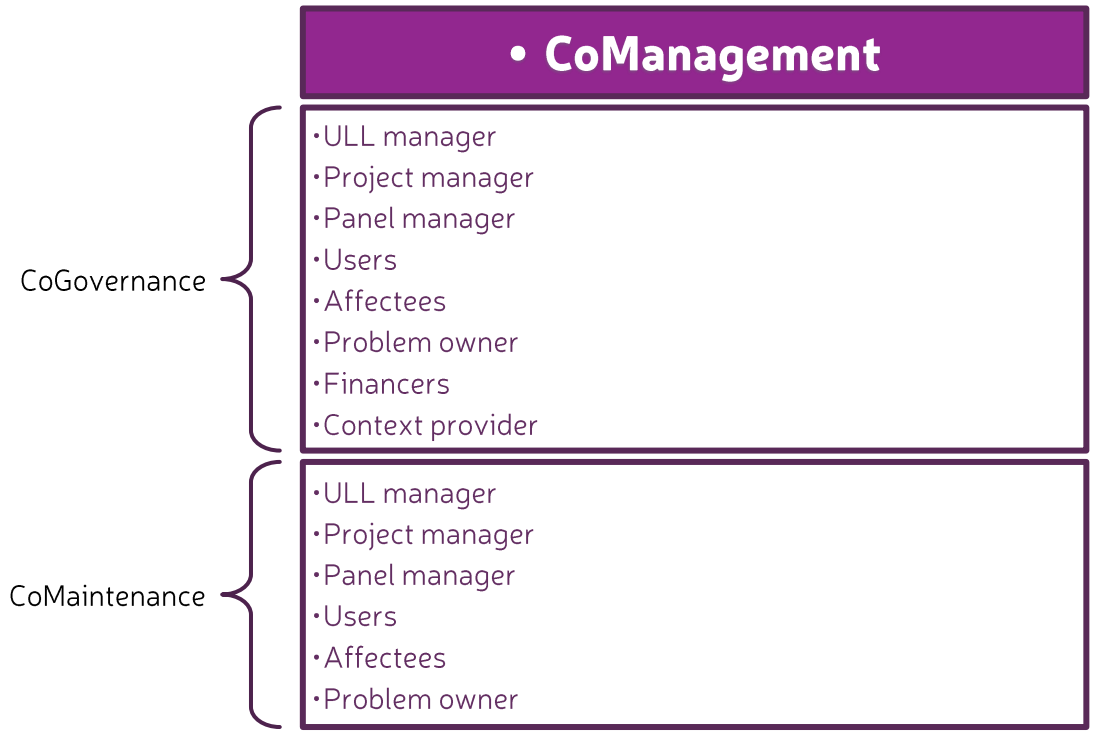

Figure 20. Stakeholders of the CoManagement stage of the LCCCP. Adapted from Ståhlbröst, Bergvall-Kareborn and Eriksson (2015)

The engagement of the stakeholders can vary during the different stages and sub-stages of the project and, as such, different tools can be used during different stages of the process. The stage in which stakeholder engagement is more prominent is during the CoDesign and CoExperiment phases, while less stakeholder engagement is needed during the CoExplore and CoImplement phases (van de Ven *et al.*, 2016). Even though an important level of engagement from the stakeholders is expected during these latter stages (mostly the planners or developers of the project), these require mostly good and open communication channels with the rest of the stakeholders. The CoManagement phase needs to promote further engagement of the stakeholders as it happens in the last period of the project. Again, good communication and engaging activities are crucial to provide the necessary tools for stakeholders to remain engaged with the solution even after the project is finished. Figure 21 shows the level of engagement that is expected by the stakeholders during each of the stages and sub-stages.

Figure 21. Level of engagement expected from stakeholders during the different stages and sub-stages of the LCCCP. Adapted from van de Ven et al. (2016) and from Ståhlbröst, Bergvall-Kareborn and Eriksson (2015)

6.4. Tools for stakeholder engagement

Given that stakeholder engagement has been identified as an important part of the benefit identification of a project, tools to promote stakeholder engagement are of high importance during the co-creation process. Benefits of co-creation are improved when multiple points-of-view are integrated, as the identified solutions are more likely to reflect the needs of diverse stakeholders and, accordingly, facilitate stakeholder buy-in to the project (Keeys and Huemann, 2017).

For the JEMES – CiSu Thesis, the main goals of the engagement process identified by Mease, Erickson and Hicks (2018) were matched with the five (5) stages of the LCCCP in order to provide a comprehensive framework for selecting stakeholder engagement tools. Some examples of stakeholder engagement tools were selected that can be used during the sub-stages to achieve the goals of said sub-stage, while promoting the engagement of the different actors. Toolkits for co-creation and user-centred design such as the one developed for the U4IoT project (U4IoT, 2018a), MindTools (MindTools, 2018) and Service Design Tools (Tassi, 2009b), were used as the main source of information. The identified tools corresponding to each of the sub-stages are described and shown in Figure 22 to Figure 26.

Tools for Stage 1: CoExplore

Objectives: promote dialogue, delegate or entrust control, engage under-represented populations, conduct research

Tools	**Spot the problem** e.g. brainstorm, crowdsource	**Preliminary research** e.g. wall of ideas	**Define problem and objectives** e.g. 5 bold steps vision canvas, tomorrow headlines	**Stakeholder mapping and analysis** e.g. actors map, social network analysis	**Project preliminary planning** e.g. wall of ideas, roadmap

Figure 22. Tools for stakeholder engagement during the CoExplore stage of the LCCCP. Objectives adapted from Mease, Erickson and Hicks (2018)

TOOLS DESCRIPTION

- **Brainstorm.** An effective tool to generate ideas on a specific issue due to the combination of a relaxed, informal approach to problem solving with lateral thinking. The tool encourages people to come up with thoughts and ideas that can be seen as crazy or non-plausible at first. When the participants feel free to relax and joke around during the activity, more creative ideas will be produced (MindTools, 2016). This tool could be complemented with the Creative Matrix which allows to expand the boundaries of the brainstorming process (Naude, 2017).

- **Crowdsource.** Used to engage stakeholders for a common goal. It is commonly powered by technologies, social media and web 2.0. It relies on the ever growing connectivity and targets large groups of stakeholders (Crowdsourcing Week, 2018). This is an evolution of participatory methods, such as workshops, focus groups or world cafés in which groups of stakeholders are put together and questioned about different questions by a moderator.

- **Wall of ideas.** Also known as research wall, design wall, research board, ideation wall, inspiration board, moodboard, pinboard. The main idea of this tool is to have a large vertical surface to display data and ideas. This tool allows a better exploration and visualisation process while gathering input from the stakeholders (van der Pijl, 2017).

- **5 bold steps vision canvas.** This tool allows for the vision of the project to be seen under a critical and realistic light. Vision themes need to be identified and concrete examples in which those themes are shown need to be described. After having the information related with the vision, the 5 bold steps that will help achieve the vision, in this way obtaining the path towards a concrete strategy (van der Pijl, 2016).

- **Tomorrow headlines.** Fictional articles published on magazines or journals in which the developers and planners project themselves in the future and try to understand what kind of impact the solution will have. This allows to understand how the solution will be presented to the users and what reactions it will cause (Tassi, 2009d).

- **Actors map.** Supports the visualization of communities, helping the actors to understand and discuss about their relative position and relations within a system. The map reveals what actors are involved in a network, how they are linked, how much influence do they have and their goals (Manichinelly, 2009).
- **Social network analysis.** Is a tool used to investigate and visualise social structures using networks. It is mostly used to investigate the relations amongst stakeholders but could also provide support when categorising them (Reed *et al.*, 2009).
- **Roadmap.** It is a flexible technique that is used for strategic and long-term planning. The end result of the tool is a structured means to explore and communicate the different components of a project such as objectives, existing and future technologies, measures, stakeholders, challenges (Phaal, Farrukh and Probert, 2004; den Ouden, Valkenburg and Postmes, 2018). As part of the UNaLab Project, individual roadmaps will be created for the 10 cities involved, but will in particular serve the follower cities as part of the replication framework (UNaLab, 2016).

Tools for Stage 2: CoDesign

Objectives: solicit feedback, promote dialogue, build trust, engage under-represented populations, conduct research, engage efficiently				
Tools	**Empathise** e.g. empathy map, journey map, 5 why's	**Define** e.g. user persona, value proposition canvas	**Ideate** e.g. brainstorm, wall of ideas, lego serious play	**Prototype** e.g. minimun viable product, hackathon, tomorrow headlines

Figure 23. Tools for stakeholder engagement during the CoDesign stage of the LCCCP. Objectives adapted from Mease, Erickson and Hicks (2018)

TOOLS DESCRIPTION

- **Empathy map.** The map is a collaborative tool developed by the consulting group in communications and businesses XPLANE. It is a collaborative tool that provides insight about potential problems that can arise in different stages of the co-creation process. The ultimate goal of the empathy map is for stakeholder to empathise with another stakeholder in order to gain insight into the different aspects of their sensory experience (XPLANE, 2018).
- **Journey map.** Is a tool used to create a narrative that follows the user interactions with the proposed solution(s). This map can help empathise with the users and better understand their needs and feelings, and provides a visual representation of the elements that affect the user's experience (Frick, 2017).
- **5 Why's.** It's an easy and effective tool that allows the identification of the root cause of a problem. It can be used for troubleshooting, quality improvement and problem solving, being more efficient when used to resolve simple or moderately difficult problems. The tool is an interview technique that allows the researcher and participants to gain deeper understanding during the interviews (MindTools, 2015).
- **User persona.** It is a fictional representation of the ideal user or costumer. The user persona needs to incorporate needs, goals, and observed behaviour patterns of the target audience. One persona should be created for each user group (Veal, 2016).
- **Value proposition canvas.** The canvas is composed by two different sections: the costumer segment and the value proposition. It is important to always start with the costumer, as a team all the costumers should be listed first and an individual canvas should be done for each of them. After identifying the costumers, the jobs-to-be-done, pains and gains need to be identified. The canvas allows the team to think different about the users and what can be offered to them, allowing the users to also think different about the product/service provider as their needs and wishes are addressed directly (Voorhorst, 2016).
- **Brainstorm.** See Tools for Stage 1: CoExplore

- **Wall of ideas.** See Tools for Stage 1: CoExplore
- **Lego serious play.** Participants are faced with a question and asked to answer the question by building a Lego model as a metaphorical representation of their answer/ idea. The methodology is used for many purposes and facilitates the exchange of thoughts and ideas between participants from different disciplines. Lego Serious Play can be used at any stage of development, but could be described as most suitable in the beginning phases, or at pivotal points in the project where the method is rather used on discussing about experiences than creating ideas (Lego, 2018).
- **Minimum value proposition (MVP).** Is a prototyping technique in which the solution is developed with enough features to satisfy early users. The complete set of characteristics of the solutions is only designed and developed after receiving enough feedback from users. It is the first prototype made (Forbes, 2018).
- **Hackathon.** An event of any duration in which people get together to solve problems. Using a competition scenario, participants are faced with a question or objective and asked to answer it by coming up with a solution to it. The concept is similar to the Lego Serious Play but the Hackathon is done in a larger scale as the participants are asked in many cases to come up with a prototype of the solution they are proposing (MindTools, 2015).
- **Tomorrow headlines.** See Tools for Stage 1: CoExplore

Tools for Stage 3: CoExperiment

Objectives: solicit feedback, promote dialogue, build trust, engage under-represented populations, conduct research, engage efficiently, ensure compliance		
Tools	**Experiment** e.g. I like, I wish, what if; planning support systems	**Decide** e.g. cool wall, dotmocracy, planning support systems

Figure 24. Tools for stakeholder engagement during the CoExperiment stage of the LCCCP. Objectives adapted from Mease, Erickson and Hicks (2018)

TOOLS DESCRIPTION

- **I Like, I Wish, What if.** Is a facilitated team feedback method in which feedback is collected in a constructive and positive form. It was initially designed to suit interdisciplinary teams by creating an easy to use format in which everyone feels comfortable. Because of the positive connotation of the statements I like, I wish, What if, the participants that are usually uncomfortable with sharing direct criticism, feel comfortable with this format (Dam and Siang, 2018b).
- **Cool wall.** The Cool Wall consist of a large poster on which participants can stick cards. The cards contain images of the neighbourhood (e.g. day and night situations) and potential solutions for inspiration. Also, empty cards are provided for people to add own ideas. The wall has four categories: seriously uncool (not nice at all), uncool (not so nice), cool (nice) and sub-zero (really nice). Participants choose cards they find interesting and write what they do in that area, and why they like it or don't like it there (TU/e LightHouse, 2017).
- **Dotmocracy.** Is an established facilitation method used to vote with dot stickers or with a marker pen. It allows all participants to vote for one or more ideas that they like,

being a quick and simple method to prioritise a long list of options. The tool helps to create a sense of engagement on the participants as they feel directly responsible of the decision and allows them to take part of the decision process (Dotmocracy, 2017).

- **Planning support systems (PSS).** Developed as computer-based geo-information instruments that assist planners in the process of making decisions, helping them to explore and manage their activities (Geertman and Stillwell, 2004). As described by Russo *et al.* (2018, p. 10) PSS are *"a decision support tool to assist data-driven land use planning"*. As part of the UNaLab Project, the Systemic Decision Support Tool (SDST) is being developed as a scenario simulation tool that will allow to assess the impacts, benefits and co-benefits of NBS in the face of population growth and/or climate change (UNaLab, 2016).

Tools for Stage 4: CoImplement

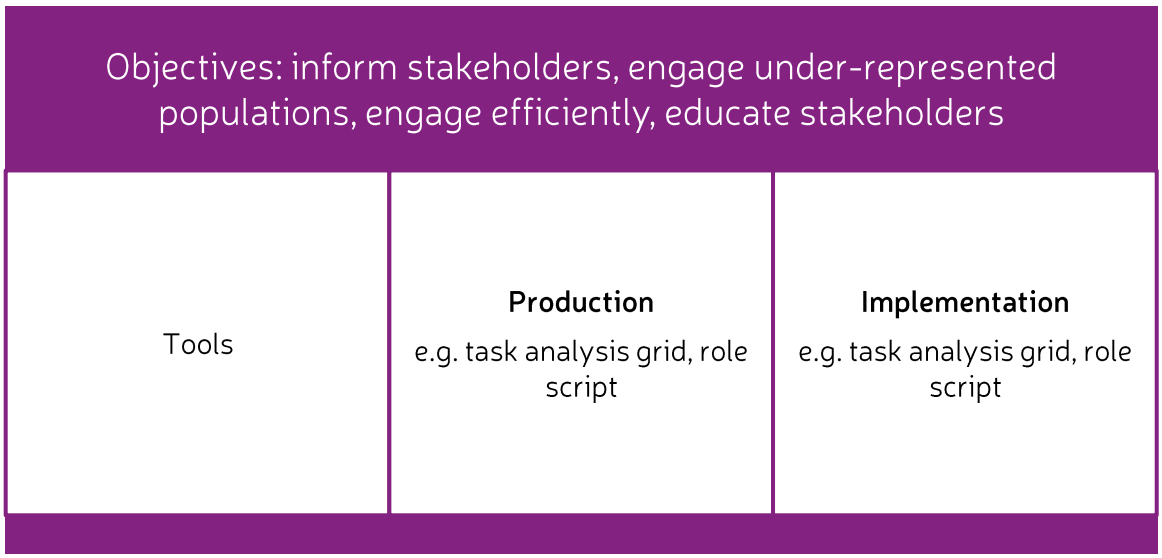

Figure 25. Tools for stakeholder engagement during the CoImplement stage of the LCCCP. Objectives adapted from Mease, Erickson and Hicks (2018)

TOOLS DESCRIPTION

- **Task analysis grid.** The aim is to show in a unique schematic way all the information and scope of the project, as well as the stakeholders related with each part of it. Each column represents a scenario, describes the task and it's followed by all the sub-tasks needed to complete the task. They can be colour-coded and prioritised and as such

allows the stakeholders to easily understand where are they involved and what they need to do (Tassi, 2009c).

- **Role script.** This tool provides the stakeholders with a series of scripts, one for one situation that they could meet. It represents a scenic representation of the situation and instructs the stakeholder on what to do with notes, comments and advices (Tassi, 2009a).

Tools for Stage 5: CoManagement

Objectives: inform stakeholders, delegate or entrust control, engage under-represented populations, engage efficiently, ensure compliance, educate stakeholders		
Tools	**CoGovernance** e.g. actors map, role script	**CoMaintenance** e.g. actors map, role script

Figure 26. Tools for stakeholder engagement during the CoManagement stage of the LCCCP. Objectives adapted from Mease, Erickson and Hicks (2018)

TOOLS DESCRIPTION

- **Actors map.** See Tools for Stage 1: CoExplore
- **Role script.** See Tools for Stage 4: CoImplement

As noted in the tools shown above, some of them (e.g. brainstorm and wall of ideas) can be used during more than one sub-stage due to its versatility. It is important to notice that the tools identified during this section do not cover the complete universe of tools available but intend to show a small sample of the ones available.

7. Conclusions and recommendations

The objective of this study was to identify and characterise the stages in the life cycle co-creation process (LCCCP) of nature-based solutions (NBS) for urban climate change adaptation, including the stakeholders and the tools that can be used to promote stakeholder engagement on each stage. Stages and sub-stages of the LCCCP were identified and defined building on continuous improvement approaches, such as the PDCA cycle (Kaizen™), the DMAIC cycle and the Design Thinking methodology. At each of these stages and sub-stages, the stakeholders involved were mapped based on the internal and external actors of the Urban Living Lab (ULL) approach. Examples of stakeholder engagement tools, proposed to be used at each of these stages and sub-stages, were based on the goals of stakeholder engagement (Mease, Erickson and Hicks, 2018).

This study goes beyond previous studies in various ways. First, a unique co-creation path, named the LCCCP, was created using continuous improvement approaches and the Design Thinking methodology. The LCCCP starts with the identification of the problem or problems that need to be addressed using a co-creation process, and finishes when the tool has been implemented and has being managed by the stakeholders. In contrast, the Design Thinking methodology as most previous studies do, only covers some of the stages (van de Ven *et al.*, 2016; Russo *et al.*, 2017; Dam and Siang, 2018a).

Second, the main actors that should take part of each stage and sub-stage were identified using the ULL internal and external actors, which were identified by Ståhlbröst, Bergvall-Kareborn and Eriksson (2015). The level of engagement expected from the stakeholders was also identified (adapted from Ståhlbröst, Bergvall-Kareborn and Eriksson, 2015; van de Ven *et al.*, 2016).

Third, the main goals for stakeholder engagement described by Mease, Erickson and Hicks (2018) were adapted for each of the LCCCP stages and examples of tools that could help achieve those goals were provided.

Finally, this study is the first one of its kind that attempts to provide a complete overview of the co-creation process while also providing the actors that should take part of the stages, as well as examples of tools to promote stakeholder engagement on each stage.

The creation of the LCCCP, carried out during the JEMES – CiSu Thesis proved that a parallel between the PDCA and DMAIC cycle, and the Design Thinking methodology can be made. The co-creation path of five (5) stages that was developed including most of the stages described on both cycles and the methodology, create a unique path that can be followed by co-creation practitioners. The developed LCCCP comprises the following stages: co-explore, co-design, co-experiment, co-implement and co-manage.

The LCCCP provides a unique path that identifies the stages, actors and engagement tools for co-creation in one study, and as such it can provide a comprehensive and easy to follow guide for co-creation practitioners. Practitioners with little or no experience at all will be highly benefited as they can follow it step by step without the risk of missing important milestones of the co-creation process due to lack of experience.

Given that co-creation is considered to be the way forward with environmental related issues (Sanders and Stappers, 2008; Krogstie *et al.*, 2013; Voorberg, Bekkers and Tummers, 2015; Le Feuvre *et al.*, 2016; Russo *et al.*, 2017), and that it has been identified that a methodology that supports co-creation is needed in order to ensure its success (Bradwell and Marr, 2008), the LCCCP developed during this study, is a comprehensive and well-defined co-creation process that can be used to develop NBS and as such, it can contribute to more sustainable and resilient cities in the face of global change.

It is of high importance to have a deep understanding of the different roles that stakeholders can adopt during a co-creation process in an ULL. How this selection of the actors can be made for the JEMES – CiSu Thesis has not been considered in detail, but should be taken into careful account within the process. The actors may vary depending on the ULL, the stakeholders that will be taking part of the process and the project that will be developed.

Many different tools for stakeholder engagement can be found in the literature and even though plenty of information and step-by-step guides are available, identifying the most

optimal tool requires experience and practice. The real experience of adopting co-creation and applying the tools in real life settings is a significant part of the knowledge needed to identify the optimal tools. Further research is needed in order to create a specific framework for stakeholder engagement tools in which the main objective of the tools and selection criteria according to the objectives can be described.

The tools provided in this JEMES – CiSu thesis are to be considered examples and not a definite list of tools. Literature provides several different examples of tools that can be used for stakeholder engagement. It is important to understand that every tool that is available at the moment can be tailored to meet specific goals and according to the stakeholders, and as such they should be considered to be in continuous development and evolution.

As a general recommendation, an expert in Design Thinking and user-centred design (UCD) needs to take part of the co-creation process as he/she will be equipped to participate in most of the stages of the LCCCP and apply the most suitable tools for stakeholder engagement.

Some caveats remain. First, as the LCCCP has not been applied, feedback from practitioners needs to be obtained. Further development of the stages and sub-stages identified for the LCCCP needs to be done in order to gain a better understanding of the outputs and deliverables expected from each of them. This will allow new practitioners to acquire a reference framework that will help them to apply co-creation in the identification, development and implementation of NBS and other solutions. For this, direct feedback from co-creation practitioners needs to be obtained in order to fine tune the LCCCP developed.

Second, it is important to develop a monitoring structure in which the LCCCP can be constantly analysed to determine how successful the process is. Given the case that a stage or sub-stage hasn't achieve its goals, the monitoring structure should provide the necessary information in order to identify the fails and how to solve them.

Finally, a literature review of co-creation related studies needs to be done to compare them with the LCCCP. A mapping of the studies along the LCCCP to indicate which stage(s) are considered, what stakeholders are involved and what tools are used can provide additional input in order to further develop the co-creation path.

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